

Designing and evaluating a user interface for continues embedded lifelogging based on physical context

Thesis by
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Abstract

An increase in both personal information and storage capacity has encouraged people to store and archive their life experience in multimedia formats. The usefulness of such large amounts of data will remain inadequate without the development of both retrieval techniques and interfaces that help people access and navigate their personal collections. The research described in this thesis investigates lifelogging technology from the perspective of the psychology of memory and human-computer interaction. The research described seeks to increase my understanding of what data can trigger memories and how I might use this insight to retrieve past life experiences in interfaces to lifelogging technology.

The review of memory and previous research on lifelogging technology allows and support me to establish a clear understanding of how memory works and design novel and effective memory cues; whilst at the same time I critiqued existing lifelogging systems and approaches to retrieving memories of past actions and activities. In the initial experiments I evaluated the design and implementation of a prototype which exposed numerous problems both in the visualisation of data and usability. These findings informed the design of novel lifelogging prototype to facilitate retrieval. I assessed the second prototype and determined how an improved system supported access and retrieval of users' past life experiences, in particular, how users group their data into events, how they interact with their data, and the classes of memories that it supported.

In this doctoral thesis I found that visualizing the movements of users' hands and bodies facilitated grouping activities into events when combined with the photos and other data captured at the same time. In addition, the movements of the user's hand and body and the movements of some objects can promote an activity recognition or support user detection and grouping of them into events. Furthermore, the ability to search for specific movements significantly reduced the amount of time that it took to retrieve data related to specific events. I revealed three major strategies that users followed to understand the combined data: skimming sequences, cross sensor jumping and continued scanning.

DEDICATION AND ACKNOWLEDGMENTS

I would like to dedicate this thesis to the memory of my mother and my father, who are a constant source of inspiration.

I would like to acknowledge the inspirational instruction and guidance of Professor Dr. Patrick Oliver who has given me a deep support and appreciation for the beauty and detail on this subject. There is no doubt in my mind that without his continued support and counsel I could not have completed this process.

I would like to thank my wife for her support and encouragement. I could not have completed this effort without her assistance, tolerance, and enthusiasm.

Lastly, this thesis is dedicated to my children. It is hoped that through this work, one day, you may understand why I was not with you during some of the important years of your lives.

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Chapter one

Introduction

1.1 Overview

Peoples' lives are crowded with things that they need to keep track of. To remember them, they make use of lists, diaries and notes, as well as emails, phone calls, PDA's, and wearable sensing devices. This encourages scholars and researchers to design and investigate Prosthetic memory (PM) to support human Organic Memory (OM) and assist people in remembering their everyday experiences, such as conversations, learning new materials or skills, and remembering personal past actions, activities and events.

PM technology designers consider three main fields: Computer Science, Psychology research in organic memory, and Human Computer Interaction (HCI). The research presented in this thesis attempts to bridge these research areas to address the following questions: What data and metadata could augment human memory and how? How could lifelogging data be presented visually to support users in recalling their past experience? How could users create different strategies to generate valuable cues that trigger their memory, allowing them to access and describe more details of their past events or memory? What are the long-term benefits of using such technology? And how can I develop a better user interface to augment and support autobiographical memory?

This chapter introduces research objectives and motivation, and establishes the contribution of the work.

1.2 Research Objectives

The process of lifelogging an individual's experience is not limited to personal actions and activities only: community experience could be also digitally recorded and archived for later use. I believe that lifelogging and electronic memories are going to have a significant impact on people's lives, similar to the revolution of the internet and mobile phone. The main objectives of this study are:

- To increase my understanding of human memory and the roles that are performed to manage personal information—what data could trigger human memory and how?
- To develop an increased understanding implication of human memory in the the design of lifelogging technology and applications. These insights could help us to introduce new methods of capturing valuable data and metadata from people's environments that could offer a creative opportunity to augment human memory.
- To capture individuals' data and their environment's metadata with artificial sensors to provide an effective method of storing, archiving, and establishing that data as external memories.
- To integrate both the capture and retrieval of lifelogging technology in the support of people's memory and enhancement of their lives through new and natural technology.
- To study the use of an episodic user interface for accessing heterogeneous data captured from everyday activities and actions, and also to be aware of how people could use it to create interactive cues that are able to augment, trigger and simulate their memory.
- To design, build, and evaluate an interactive lifelogging prototype that can be easily mastered and assist ordinary people of different ages in creating values and interactive cues to access and retrieve their memories.
- To develop the software agents to create a lifelong interactive interface that is able to communicate different types of data, in order to reduce complexity, enhance retrieval recognition, and improve reflection.
- To discuss, design, and implement the prototype functions to be sure that they have efficiently performed and worked over a long period of time.

1.3 Motivation

Nowadays, lifelogging vision extends beyond desktop objects, and we are increasingly surrounded by digital devices that have the ability to passively capture and collect different personal interaction and easily store past events and actions. In addition, recent advances in sensor networks, mobile computing, and generated and archive data could enable people to capture everyday events and activities digitally, without being at their computers (Sellen & Whittaker, 2010); (Bell & Gemmell, 2007). Likewise, both capture technology and storage capacity are improving rapidly. For example, digital cameras and storage are getting smaller and cheaper, while wireless connectivity is becoming more ubiquitous. Therefore, lifelogging data that is collected from such devices needs to be investigated and assessed to see how people could use such information to augment and trigger their organic memory (OM), so that I can understand the methods that people follow to create their visual cues from the available data and how they use them to retrieve their past life experience. I believe that such cues could support people in mentally travelling back in time, and enable them not only to retrieve their past actions and events, but to relive their past emotions and feelings as well.

1.4 Statement of Thesis

This study addresses the problem of augmenting and supporting individuals' biological memory systems by using a computer. Such techniques should assist people in capturing, storing, and archiving moments in their lives. In addition, they should trigger their memory to retrieve past events, introducing values and interactive cues that are able to simulate and trigger their biological memory to access extra information and details about specific events.

A further objective of the study is to confirm that lifelogging could not only support people in retrieving their past events and action, but also help them to mentally project themselves back in time and relive their past experience. This means it has the potential to be very useful for people with conditions that cause memory loss, such as Alzheimer's disease, but could be useful for people who do not have such conditions as well. I show that, in a personal autobiographical memory, the focus tends to be on people rather than things or places. The proposed system is evaluated through two case studies using real-life participants in order to improve my understanding about the

nature of the research problems and the extent to which the software is successful in providing support.

1.5 Contributions

As a part of a research effort in the field of Human Computer Interaction (HCI) to create effective lifelogging technology, this research concentrates on collecting meaningful data and metadata that could be used to create interactive cues that are able to simulate human memory for the retrieval process and the reliving of past experiences. In addition, it introduces a new user interface to present that data visually. My strategy in pursuing this goal is to build and evaluate a new lifelogging system with real users to assess the value and the usability of every data collection method, as well as the interface. The main contributions of this research could be classified as follows:

Memory – Improving an understanding of the role of human memory. The first objective of this doctoral work is to learn more about memory and attention to establish a clear understanding of how human memory works? and the implication of this for the design of lifelogging technologies and applications.

Lifelogging Technology – Improving my understanding of previous lifelogging systems and the challenges they present.

Design, build, and evaluate lifelogging prototype – This part contributes to the HCI community by designing, building, and evaluating a novel lifelogging interface to represent lifelogging data as events in visual format. These events might assist people in better memory augmentation and better user modelling. In this section I need to highlight that with lifelogging technology, capturing annotation could not only present collected data as events, but enable life-loggers to reflect on their retrieved memories, as they should be able to search, create visual cues and browse their collection easily. The necessity of accessing and presenting lifelogging data to users as events has been previously mentioned as a challenge area in HCI (e.g, Sellen et al., 2007; Lamming et al., 1994; Kalnikaite et al., 2010), and only a limited number of user interfaces have been built and investigated for this purpose. I first designed, built, and evaluated the ability and usability of the most common lifelogging data and metadata that is used to augment human memory, and then I carried out a field trial evaluating the capture and organisation of personal memories. I established the benefits of using each different type of data and the strategies users follow to create their memory cues.

1.6 Main Questions Evaluated

The main objective of this thesis is to support people in remembering past actions and activities with the use of an interactive software system. I raise a number of questions:

- What data and metadata could be used to trigger and simulate human memory?
- What devices could be used to capture lifelogging data, how could they capture it, and for how long?
- Does collected data support long-term memory?
- How can I determine whether such data reflects upon a users' lifestyle?
- Does processed data add more influence to trigger human memory?
- How could I build an interactive interface to introduce that data collection in a visual manner, and how should I formulate that data so that it can simulate and trigger human memory?
- Does the system introduced in this thesis support, augment, and trigger people to remember their past life experience?

1.7 Structure of the Thesis

The thesis is structured as follows:

Chapter 2: An Overview of Human Memory. This introductory chapter presents an overview of psychological research into human memory, provides a general idea of human memory and everyday memory problems, and presents an explanation of how human memory works. It distinguishes between different types of memory and the ways in which people mentally store and retrieve information. It also explores the strategies that people used to augment their memory in the past, and discusses how technology could be used as a memory aid to augment and enhance the performance of memory tasks.

Chapter 3: An Overview of Lifelogging. This chapter introduces and outlines the topics addressed in the thesis by surveying related work. It explores and highlights an overview of past systems that have been presented in the art of lifelogging technology, and reviews content architecture, the technical challenges encountered, and how they

were solved. This chapter aims to understand and evaluate the benefit of using raw data and metadata to trigger human memory, as well as build and assess the user interface to investigate different strategies that users follow to create cues to achieve their goal.

Chapter 4: Approach. This chapter introduces Human Computer Interaction and the idea of applying HCI to lifelogging technologies. It describes the thesis methodology and explores the different approaches that I used, illustrating the reasons for using each of them to answer my research questions. Moreover, it summarises the most important characteristics of the study, such as participants, analysis, and finding.

Chapter 5: First Prototype. This chapter aims to better understand how different types of raw data and metadata could assist people in generating their visual cues. It monitors and follows the individuals' behaviour and strategies to understand the ways that they create their visual cues. It also presents the interactive design of a novel lifelogging interface to examine how ordinary people could use the system in practice, and to observe and understand their behaviour and interaction with the system. This chapter extends the notion of lifelogging to include photos, location information, emails, computer activity, phone calls, and text messages (SMSs).

Chapter 6: Second Prototype. This chapter aims to develop and improve the usability and productivity of the previous prototype by adding extra values, processed data and metadata to estimate peoples' activities. It redesigns and builds an appropriate and suit user interface that permits interactive searching and browsing and is capable of encouraging users to create values cues that trigger and simulate users' memories, allowing them to respond to data and utilise it as a series of bookmarks to gain further information about their past life experience.

Chapter 7: Evaluation of the second prototype. This chapter aims to assist the second prototype and discuss how the visualisation of the movements of the users' hand and body and the movements of objects could help group activities into events when combined with the other data captured at that same time. In addition, it reveals the major strategies that users follow to create their visual cues to retrieve different types of memory.

Chapter 8: Contributions, Conclusions and Future Work. The final chapter contains further discussion of the contributions, and presents the conclusions and the future areas for exploration that stem from this work.

Chapter 2

Overview of Human Memory

2.1 Introduction

Memory and awareness are becoming more essential resources for wellness, especially given the continually increasing information overload that people must deal with, and the fact that human memories are not improving. In this chapter I will provide an overview of human memory and everyday memory problems. I believe that managing and organising vast amounts of lifelogging data requires a basic understanding of how human memory works; therefore, I need to establish this understanding, as well as distinguish between different types of memory. In addition, clear understanding of human memory could help find, and assist in the implementation of, new effective memory cues to facilitate the retrieval of information. Furthermore, the more we know about our memory, the better we will understand how we can improve it. Otherwise, we will have no idea of what we are trying to augment.

The main goal of this chapter is to provide a good basic knowledge of the structure and the process of human memory, and also to present a comprehensive exploration of memory research. This stage will help the reader to follow and understand the subsequent chapters of the thesis.

2.2 Memory Structure and Process

Memory is a single word for a brain process by which we recall experience and knowledge. It allows us to learn from our elders, and them to learn from their elders, so that a modern person can benefit from the knowledge of generations. Loring described memory as the absorption and retention of information (Loring, 1999). Anderson defined human memory as a record of individuals' life experiences and actions (Anderson, 2000). Therefore, the memory has the ability to obtain information, process it, and archive it for later use, such as recalling past events instantly and learning from experience. Atkinson and Shiffrin pointed out that at the core of the memory process are encoding, storing, and recalling information (Atkinson & Shiffrin, 1968)."

Researchers are concerned with both the structure and process of human memory. Research into the former is focused on how memory systems are organised, while research into the latter focuses on finding out how memories are stored and retrieved. Eysenck introduced three overlapping interrelated processes associated with human memory (Eysenck, 2001). As shown in (figure 2.1) the encoding phase is the first step in creating a memory of an experience where attention is paid to sensory input and the experience is integrated with information that has been encountered before. It is classified as a set of operations that people use to code their incoming stimuli. In this process, mental representations are created from external catalysts. The second process is the “storage stage”. This step occurs as a result of the encoding. In this phase, some information is committed to human memory.

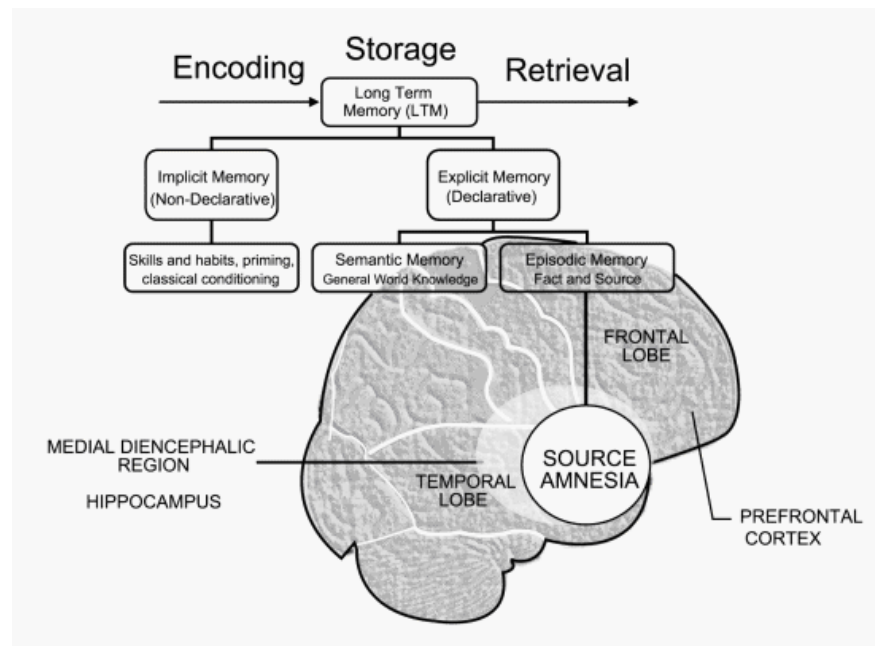


Figure 2.1 Structure and the process of human memory
(Shaheen Emmanuel Lakhan, 2007)

The final stage is information retrieval, where information stored in a person’s memory is recaptured. Tulving and Thomson pointed out that human memory can retrieve information if it has been stored and the information is available in the human memory, but that it cannot be accessed without using appropriate cues (Tulving & Thomson, 1973) Therefore, collection of digital data such as time, location, people, activities (*what* and *where*), and event information can serve as cues to trigger human memory about past experience, but are not memories in themselves.

For instance, a memory could be triggered by a sound, touch, taste, smell, colour, or a particular scent that enables someone to recall a past experience and relive the same feeling as when the memory was born. Tulving and Thomson illustrated that the retrieval process completely depends on the indexing of data and methods of storage (Tulving & Thomson, 1973). Thus, human memory is not analogous to conventional digital data storage although some context-based retrieval have attempted to mimic memory.

Eysenck suggested that there is no structure without process. Thus, the act of remembering an event occurs as a result of a relation between the storage and retrieval stage (Eysenck, 2001). For instance, when remembering one's childhood or a period of travelling, distinctive smells or favourite songs could work as strong cues to simulate memory for remembering past events and actions. Associative retrieval occurs when one or more previous cues bring up other memories or the contextual or emotional conditions of those previously experienced. In addition, pieces of data associated with information that one wants to remember could be used to question the retrieval process.

2.3 Human Memory Architecture

Atkinson and Shiffrin introduced a multi-store model of memory. This model is shown diagrammatically in Figure 2.2. They made a distinction between three main components of human memory according to the time span for which information remains in the memory (Atkinson & Shiffrin, 1968).

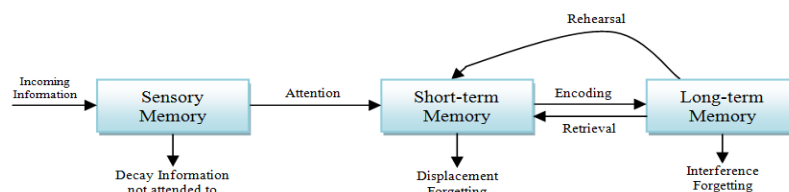


Figure 2.2 the multi-store model of memory proposed by (Atkinson & Shiffrin, 1968)

From shortest to longest lifetime, these are: sensory, short-term, and long-term memory. The sensory store can hold information very briefly, i.e. milliseconds. It can hold information from any of the five senses depending on the focus of attention for that brief time. Sensory stores are limited in capacity, with incoming data replacing older data.

These sensory outputs are available to be input to the short-term memory system. Short-term memory also has a limited capacity, and holds information in the brain for up to several minutes. After this time-span, information stored in the short-term memory will decay unless it is rehearsed.

Rehearsing information, for example by attention, repetition and associated ideas could move that information into a permanent class called long-term memory (see figure 2.3). The long-term memory has an unlimited capacity and holds information for a long period of time.

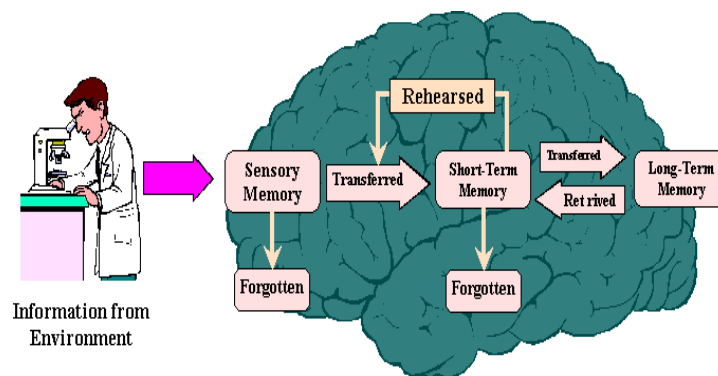


Figure 2.3 the multi-store model of memory proposed by Marzano (Marzano, 1998)

2.3.1 Sensory Memory

Sensory memory is the first level of observation and memorisation. In this stage, almost of environmental information is stored for a very brief period of time: three or four seconds for auditory information and no longer than a half-second for visual information. Baddeley described sensory memory or sensory registration as “... intimately involved in our perception of the world ...” (Baddeley, 2004). This memory maintains an exact copy of what is seen or heard (visual and auditory). It acts as a buffer for data flow from physical stimuli received through the senses for less than one second before processing it. A sensory memory exists for each sensory channel: *iconic memory* where visual data is stored for a short period of time, *echoic memory* where auditory data is stored for a short period of time, and *haptic memory* for storing data regarding touch and internal muscle tensions. Information is passed from sensory memory into short-term memory when a person pays particular attention to it, thus filtering the stimuli to only those that are of interest at a given time. This kind of

memory decays very quickly and is replaced immediately when new sensory information is registered.

2.3.2 Short Term Memory (STM)

Short-term memory works as selective attention moves information from the sensory memory to the short-term memory. This part of the memory has the capacity to maintain information for short periods of time and is used for, for example, storing phone numbers that individuals are about to dial, or shopping lists. The information is most often stored as sound, especially in recalling words, but may be stored as images. Short-term memory functions as a notepad for temporary recall of the information being processed. For example, in order to understand a sentence, we need to remember the beginning of the sentence until we read the rest.

Short-term memory has limited capacity and decays rapidly after approximately 200 ms. Peterson and Peterson proposed that items could remain for only 18 seconds in the short-term memory (Peterson & Peterson, 1959). The capacity of short-term memory suggested by Miller was around seven units (Miller, 1956). He pointed out that the capacity of short-term memory could be increased through the process of chunking. This is the reason why a hyphenated phone number is easier to remember than a single long one. Successful formation of a chunk is known as closure. Sperling noted that visual stimuli can be retained for approximately 0.5 seconds (Sperling, 1960). Darwin et al found evidence that sound information could be held for at least 4 seconds (Darwin et al., 1972).

Interference often causes disturbances in short-term memory retention. This accounts for the desire to complete the tasks held in the short-term memory as soon as possible. The big question is that of why information decays so quickly from the short-term memory. There are three principal theories for why this happens. The first is that storage is structurally limited: information has to be displaced before more data can be stored as a result of full capacity. Another theory is that the decay of information is a result of it being unused (Reitman, 1971). Finally, a person could forget information due to new information interfering with it (Waugh & Norman, 1965).

Baddeley and Hitch proposed that the concept of short-term memory should be replaced with “working memory”, which consists of three components (Baddeley &

Hitch, 1974) (see figure 2.4). The first component, central execution, is the most important component of the working memory system; this element controls the attention paid to stimuli and allocates resources. Anderson said that central execution controls two subsystems that store or retrieve memory, a visuo-spatial sketchpad and a phonological loop. The former is used to process and store visual information as spatial information. This is essential for learning new visual information such as faces, objects and spatial layouts of objects. The latter processes verbal information and is responsible for the phenomenon known as the “inner voice” and “inner ear”, which enables people to rehearse and listen to verbal information without making a sound (Anderson, 2000).

The working memory is a temporary store for visual and spatial information such as colours, shapes, or location. It is concerned with processing as well as the short-term retention of data. It explains the role of memory in activities such as mental arithmetic and comprehension. It also allows for the possibility that multiple processes can be performed simultaneously without disruption if they utilise different sensory components of working memory (Baddeley & Hitch, 1974).

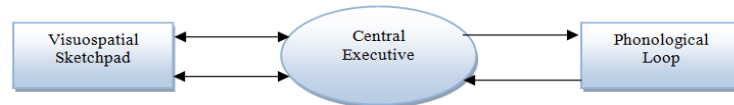


Figure 2.4 the model of working memory (Baddeley & Hitch, 1974)

Cowan proposed that the phonological loop is a part of long-term memory and that it is responsible for language learning (Cowan, 2001). Therefore, working memory plays a significant role in the learning and retention of new information, as well as storing data while processing, keeping one or more thoughts active and making it possible to create associations between thoughts. Scholars generally support the notion that information must flow into the short-term memory before entering the long-term memory.

2.3.3 Long-Term Memory (LTM)

The long-term memory is a system for permanently storing, managing, and retrieving information for later use. It is a store for holding data for periods longer than thirty seconds and could be unlimited in capacity. Atkinson and Shiffrin pointed out that information stored as long-term memory could be available for a lifetime (Atkinson & Shiffrin, 1968). Thus, the functionality and structure of long-term memory is

completely different from that of short-term memory. The capabilities of long-term memory were examined by Herman Ebbinghaus for the first time in the late nineteenth century (Ebbinghaus, 1885). He conducted and observed his own ability to remember lists of nonsense syllables after varying lengths of time, ranging from one hour to thirty-one days. Ebbinghaus noted that most of the information was forgotten after a short period of time (60% after only 9 hours), and that after this the rate of forgetting slowed (75% after one month) (See Figure 2.5).

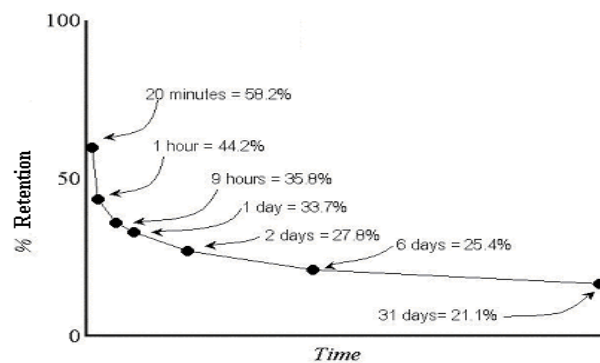


Figure 2.5 Ebbinghaus' Forgetting Curve (Ebbinghaus, 1885)

The result has been confirmed by several researchers, including Rubin and Wenzel, who tested forgetting rates for several types of data (DC Rubin & Wenzel, 1996).

Cognitive psychologists distinguish between two main kinds of long-term memory according to the type of information that is stored. Procedural memory is knowledge of how to perform certain tasks, such as how to ride a bicycle. In contrast, declarative memory consists of factual knowledge. In addition, numerous theories have been proposed to examine long-term memory and attempts have been made to answer questions, such as whether long term-memory loses information completely, as short-term memory does, or whether it just accesses data without using the appropriate trigger for helping the memory to retrieve target information. The focus of this thesis is primarily on long-term memory. The following sections discuss long-term memory types and their functions in more detail.

2.3.3.1 Explicit and implicit memories

I believe that if we rely on previous experiences and knowledge, explicit memories can be recalled. It often works as associative and link human brain together. For example,

when someone thinks of a word or occasion, such as a birthday party, the memory can bring up a whole host of associated memories, from dancing to gifts to cake and food to a thousand other things. Tulving and Schacter mentioned that information in the long-term memory is stored in two categories: explicit and implicit memories (Tulving & Schacter, 1990). The former, sometimes called “declarative memory”, refers to memories that are stored with some awareness, of events or episodes that happened to us. It allows us to remember, for instance, what happened at our 18th birthday or at our college graduation party. Implicit memory, also known as “procedural memory” requires conscious thought. Through it, a person recalls events that have occurred in the external world, such as who came to dinner last night or who won the world cup last year. Information stored in explicit memory is about a specific event that happened at a specific time and place. When informing and storing explicit memories, we associate them with previous related stimuli or experiences. Furthermore, we may remember things without being aware that we remember them. Schacter stated that implicit memory is unlike other types of memory; it is “unconscious” memory without an associated awareness (Schacter, 1987). Schacter and Benjamin et al pointed out that implicit memory could affect conscious thought and behaviour (Schacter, 1987); (Benjamin et al., 1994). Therefore, implicit memory consists of memories necessary to perform tasks or to produce a specific type of response. It is best demonstrated when performance of a task is improved. Repetition priming and skill learning are the most widely-known types of implicit memory.

2.3.3.2 Episodic memory

Episodic memory refers to the memory of emotion, events, places, and time. It is a memory system that enables individuals to remember past personal experiences and their location in time and place. This could be, for example, links to people they knew at university, or the place where they attended school. Tulving said that episodic memory allows people to mentally travel back in time and re-experience their past events and actions. “Episodic memory ... makes it possible for a person to be consciously aware of an earlier experience in a certain situation at a certain time ... the act of remembering a personally experienced event, that is, consciously recollecting it, is characterized by a distinctive, unique awareness of re-experiencing here and now something that happened before, at another time and place”. Consequently, remembering activities can involve three different cues: who was involved, what objects were involved, and what places

were involved. Using such cues could support individuals to remember and be aware of their earlier life experiences. Tulving proposed that episodic memory allows us to recall specific episodes from past events, such as what happened, where, and when (Tulving, 1972). We may, for instance, remember a trip we took, what we had for dinner last night, what the weather was like yesterday, and any other past event in which we played a part, and which we remember as an “episode” (a scene of events). Thus, the episodic memory system not only makes individuals capable of remembering past experiences, but it is also capable of mental time travel: a person can transport into the past experience, as well as into the future, a feat not possible for other kind of memory. In addition, this type of memory is more about personal feeling; a person generally recalls the way they felt during the event in more accurate terms than they recall the details of the event. That means it is easier to remember something that happened a long time ago if it had a strong emotional impact on us. For instance, we may not remember what we had for lunch two days ago, but we might remember episodes from our time in primary school and the faces and names of teachers and friends.

In their experiments, Shum and Loftus found that landmarks could support human memory in accessing past information, and using public events could assist them in confirming and increasing their ability to perform that (Shum, 1998); (Loftus & Marburger, 1983). They pointed out that remembering landmarks could not only provide better recall of past experience, but could simulate memories of the context of that event as well.

2.3.3.3 Semantic Memory

Cohen said that semantic memory holds generic and factual information, which is derived from individuals’ past experiences via generalisation or abstraction (Cohen, 1996, p.146). Parkin defined semantic memory as an individual’s general ideas, notions, and languages that constitute their world (Parkin, 1997). Tulving said that semantic memory is concerned with facts that are independent of time, place, or the context of events (Tulving, 1972). Therefore, semantic memory deals with general knowledge about the world rather than specific knowledge about individual experience. This type of memory develops earlier in childhood than episodic memory: children are capable of learning facts about the world before they remember their own past experiences. It involves general knowledge about the world, including vocabulary and verbal ability,

and information that we pick up about our environment, such as stories and myths. Therefore, people can have knowledge without remembering where or how they acquired it, something that happens frequently. Every individual knows a wide range of facts without remembering the circumstances of their acquisition. Furthermore, semantic system memory can operate (store and retrieve information) independently of episodic memory, but not vice versa. Tulving et al said that semantic memory accounts for our general knowledge about the world (Tulving, 1972). It enables us to say what we know without knowing exactly when and where we learned it: we cannot say, for instance, how we know that a cat has four legs, that the Eiffel tower is in Paris, that Tripoli is the capital city of Libya, that the pyramids are in Egypt, and that China is the most populous country in the world.

Scientists are still unsure where in the brain semantic memory is stored; some say in the hippocampus and related areas, while others think it is widely spread throughout the brain. As with episodic memory, semantic memory ranges from strong (recall) to weak (familiarity). Unlike episodic memory, semantic memory is better sustained over time, while both episodic and semantic memories are destroyed by age.

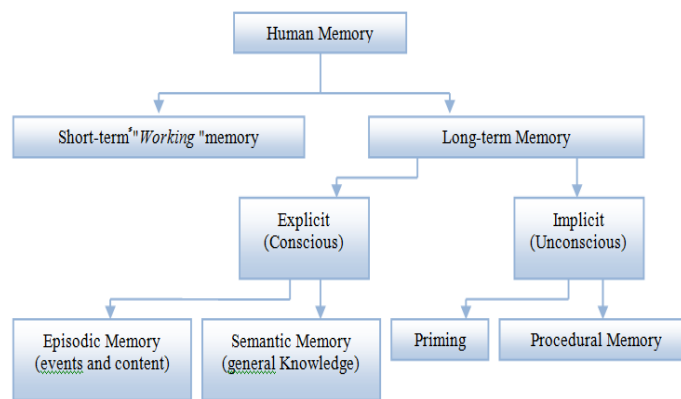


Figure 2.6 the different types of human memory

William James pointed out that habits are very important in determining our behaviour, and described the ability to perform skilled actions (James, 1893). Examples of procedural memory learning are learning to ride a bike, learning to play football, learning to swim or learning to play a musical instrument. In addition, procedural memory can be very durable, and relates to knowledge of actions, rules and procedures, which can become almost automatic with repetition. Practicing a certain task is

procedural knowledge. Often a person will learn how to perform a task but will have no awareness of how they learned it.

2.3.3.4 Priming

This class of memory is a declarative memory; it is a type of implicit memory. Squire et al said that, “Priming refers to an improved facility for detecting or identifying perceptual stimuli based on recent experience with them.” (Squire et al., 1993, p. 478). They examined priming memory by showing pictures and list of words to the subjects and then compared their performance for old and new items. They found that subjects could remember and name old items better than new ones.

2.3.3.5 The Relationship between Episodic and Semantic Memory

The episodic and semantic memories function in distinct but interdependent ways. Tulving suggested that episodic memory is embedded within semantic memory and both kinds of memory are interacting with each other (Tulving, 1972). In his study of episodic memory, Linton found that over time there was a decrease in episodic memory through repeated events, while semantic memory increased (Linton, 1982).

2.3.4 Prospective and Retrospective Memory

Explicit and implicit memories are used for remembering the past and the future respectively. Retrospective and prospective memories are associated with episodic as well as semantic memories. Thus, retrospective memory is defined as the memory of past events and actions. It involves memories of almost everything that people have done in the past, while prospective memory is a memory of future events, which can be either time-based or event-based. Time-based prospective memory is concerned with actions to be performed at a specific point in time. For example, “It’s my son’s birthday on Monday, I must remember to buy present for him”. Event-based prospective memory is concerned with actions to be performed when specific conditions are met. For example, “I must remember to buy milk when I pass the supermarket on the way home from University tonight”. Sellen et al pointed out that prospective memory is highly dependent on the deliberate use of cues (Sellen et al., 1997). The cues could be either event-based or time-based. With the former, a memory of a specific past experience acts as a cue for some other future actions or plan future activities. With the latter, a time-

based cue is used to remember past and future events—for instance, remembering to attend a lecture at 11:00am or remembering a dentist appointment at 3:00pm. Thus, prospective memory consists of recalling events, actions, or intentions that are triggered by people, places, times, or events, or a combination of two or more, to remember future plans such as running errands, sending an email to someone, remembering to take a medicine at specific times, remembering to show up for an appointment, or remembering to buy some food on the way home, including what food and at which shop. Retrospective memory, meanwhile, specialises in the retrieval of past experience, and is triggered by people, places, times or events to allow people to relive, retrieve and remember past actions and events.

2.4 Remembering

The previous sections provided an overview of memories and their structure and functions. This section focuses on another important aspect of memory: remembering. What does it mean to remember something? What strategies do people use when they consciously try to bring something back to their mind that they are sure is “there” somewhere but not remembered? The answers to these questions explain what processes need to be supported in augmented memory systems and provide a basis for the interactive design of such systems. The remainder of this section first describes recollections as the product of the process of remembering. It then describes the process itself. There are two main theories about the recall process: copy theory and reconstruction theory. Proponents of the copy theory believe that retrieving existing and fixed memories could support people in remembering their original experience. In contrast, proponents of the reconstruction theory believe that remembering is a reconstruction of likely experience. Gardiner and Richardson pointed out that remembering is accompanied by a strong subjective feeling of at least partially experiencing the original event again; this type of remembering is referred to as “reliving” (Gardiner & Richardson-Klavehn, 2000). The process of remembering is frequently triggered by a cue, and an individual does not necessarily need to be aware of the cue or of the process itself in order to remember. However, the process can also be triggered without any effort or obvious cue; this is called “spontaneous recall”. Conway described remembering as “retrieval mode” (Conway, 2001). He said that retrieval occurs in a feedback loop where cues trigger the activation of associated information.

The loop terminates when some verification criteria are satisfied, and this process may occur consciously or unconsciously.

2.5 Difference between memory loss and forgetting

Memory diminishes with age because neurons die off as people become older. For instance, people over the age of 65 have an increased risk of some diseases and brain injuries that cause loss of memory and may negatively affect the ability to learn new skills. This is called dementia. There are several causes, but the most common one is Alzheimer's disease. The process of forgetting occurs as a result of a weakness in the encoding process and lack of the retrieval cue needed to stimulate the memory. It has benefits in some cases, sometimes helping people emotionally and socially.

Researchers recommended three strategies to cope with losing one's memory. First, to search for ways to stop neurons from dying. Second, to stimulate the growth of new neurons. Finally, to find a way to make the remaining neurons function more efficiently.

2.6 Everyday Memory Problems

Everyday memory problems could happen as a result of daily activities. I believe that memory problems could affect people in different ways. For instance, memory loss causes a variety of difficulties with everyday living and relationships. These difficulties can cause a great deal of distress for the person affected. Eldridge et al and Terry categorised everyday problems into three types: retrospective memory problems, prospective memory problems, and action slips (Eldridge et al., 1992); (Terry, 1988).

Problem	Frequency	Description	Example
Retrospective Memory	47%	Remembering past events or information acquired in the past	Forgetting someone's name, a word, an item on a list, a past event.
Prospective Memory	29%	Failure to remember to do something	Forgetting to post a letter, forgetting a lunch appointment
Action slips	24%	Very short-term memory failures that cause problems for the actions currently being carried out	Forgetting to check the motor oil level in the car before leaving on a trip

Table 2.1 Eldridge's classification of common memory problems in the workplace (Eldridge et al., 1992)

They performed a study of 100 people who submitted a total of 182 separate memory problems. Table 2.1 shows their results. I argue that memory problems cannot be cured, but that it is possible to use external memory aids to help their users live as normally as possible.

2.6.1 Retrospective memory problems

Retrospective memory problems refer to the ability to remember information from past experience; people with retrospective memory problems forget details of past events or information acquired in the past. For example, they may forget the name of someone who was just introduced to them, their reason for being in a particular place, an address, items in a list, or a past experience or event. They may misplace items such as keys, glasses, or mobile phone. People who have impaired prospective memories have to depend on another person or external memory aids to assist them in remembering to do things in the future. Squire et al said that retrospective memory is thought to employ different types of memory functions or systems, such as implicit or explicit, semantic or episodic, depending on the characteristics of the information to be retrieved (Squire et al., 1993).

2.6.2 Prospective memory problems

Prospective memory problems can come in many forms: for instance, difficulty remembering a plan of action (Cohen, 1996), difficulty remembering intentions (Kvavilashvili, 1998); (Einstein et al., 1998), difficulty realising delayed intentions (Ellis, 1996) and trouble with remembering future actions (Einstein & McDaniel, 1996). Groot defined prospective memory as an ability to remember to carry out previously planned actions in the future (Groot et al., 2002). Prospective memory problems are thus concerned with a failure to remember a future task, such as forgetting to pass on a message to someone, forgetting to pay bills, forgetting about an appointment, or forgetting a bank or a lunch date.

Meacham and Leiman divided prospective memory into two types of memory: habitual and episodic (Meacham & Leiman, 1982). Habitual tasks are routine tasks: remembering to brush one's teeth before sleeping, or switching off a mobile phone before a meeting. Episodic tasks are less frequent tasks, such as remembering to buy a birthday card or a gift for a wedding anniversary. Ellis divided prospective memory

tasks into “pulses” and “steps” (Ellis, 1988). She said that pulses must be completed at a particular time while steps could be completed within a much broader time frame. Baddeley proposed that there is no difference between prospective and retrospective memory (Baddeley, 1990). Ferbinteanu and West also said that retrospective and prospective memory are the same, as both involve similar neural structures (Ferbinteanu & Shapiro, 2003); (West & Krompinger, 2005). Craik and Kerr reviewed the differences between retrospective and prospective memory in encoding, retention and retrieval processes (Craik & Kerr, 1996). They found that the fundamental processes do not differ except for a few details. For instance, during the encoding phase, there is a difference in dependence in the planning process: it is dependent on external cues and encoding intention instead of on events or facts. Einstein said that external cues may act as triggers of the intention and increase dependence on self-intention (Einstein et al., 1998). Dobbs and Reeves suggested that prospective memory has at least six main stages (Dobbs & Reeves, 1996). They listed them as follows: knowledge about the memory task, planning to archive the requirement of the memory task, determining whether the current context matches the required context, the task demand, performing the task demand, and determining whether the task has been performed on time.

2.6.3 Action slips

Action slips are concerned with very short-term memory failures that cause problems for the actions currently being carried out. This problem could occur when, for instance, actions are interrupted and individuals cannot complete it as a result. An action slip can also be caused by loss of intention to complete an action while it is carried out.

Margery Eldridge found that just under 50% of problems collected were retrospective memory problems, and that the most common problems were forgetting names, misplacing objects, and forgetting past experiences or events (Eldridge et al., 1992). They found that prospective memory problems accounted for just less than 30%, and action slips accounted for just over 20%. Therefore, technology could be used to augment and enhance any of these three categories of memory problems. For instance, to help with retrospective memory problems, preserved records of past events could be used to activate individual’s memory, and an effective way to retrieve the information could be developed. Recorded events could help individuals to recall whether they attended a particular wedding, whose wedding, who was there, and where it was.

2.7 Autobiographical memory

Conway and Rubin said that autobiographical memory is well known as a memory of the events of an individual's life experience (Conway & Rubin, 1993, p. 103). They added that autobiographical memory is mostly episodic but also contains some semantic aspects, and its functions and structure are different from other aspects of long-term memory. Conway and Pleydell-Pearce said that autobiographical memory is strongly connected to the self, meaning it has numerous functions that affect and provide the person with a sense of self. In addition, it can enable the individual to predict the future based on their past actions and activities, and enable people to share memories with family, friends, and others (Conway & Pleydell-Pearce, 2000). Cohen and Conway both see the information in autobiographical memory as being organised hierarchically into lifetime periods, events and event-specific knowledge (Cohen, 1996, p. 152); (Conway & Pleydell-Pearce, 2000).

2.8 Memory Encodings

The main objective of the memory encoding process is to link and associate context with an existing knowledge of sensory data to make it easier to remember.

2.8.1 Memory for Pictures

Human memory has two types of encoded information: verbal and pictorial. Paivio said that words are encoded with verbal information only, while pictures are encoded with both verbal and pictorial information. Pictures are therefore better remembered because they are associated with extra code, which gives them an advantage during the retrieval process (Paivio, 1991). Elswailer et al stated that pictures have richer interactions than text (Elswailer et al., 2005). I believe that a picture is worth a thousand words—one picture can provide enough information to express many thoughts.

2.8.2 Memory for Conversation

Recollection of conversations forms a critical part of human memory. People assume that they can remember the conversations they hear without noting them down or archiving them in an external memory device for later use. Much research has been done to investigate how people remember their everyday conversations. For instance, Stafford and Daly found that anxiety, focus, and social skills could influence people's

memory for conversation (Stafford & John, 1984). Conway and Bekerian found that the importance of the topic could influence how well people remember conversations (Conway & Bekerian, 1987). Sachs found that people tend to remember the general idea of a conversation rather than verbatim information (Sachs, 1967).

2.8.3 Memory for Dates

People often archive their autobiographical memories in terms of time, which could enable them to travel back along their mental timeline and recall past events and actions. Rubin said that there is a part of autobiographical memory that is specifically for dates (Rubin, 1988). He assessed a sample of events that participants recalled and dated against their own diary records and he found that 74% were within a month of being correct.

2.8.4 Memory for Places

Brewer said that places, people, and events are stronger cues than time to simulate and trigger human memory to remember a past experience (Brewer, 1988). Cohen et al also found that people and places are better remembered than time (Cohen et al., 1993). They found that holidays and childhood places are the most memorable.

2.8.5 Emotional Memory

All the types of memory mentioned above are interconnected through pathways in the brain. For instance, when people experience important moments, the brain will record not only information about that event (where, when, what, and how) but the personal emotion at that time as well. I believe that people are naturally better able to remember events that have emotional links. In addition, emotional experience, whether good or bad, leaves a strong trace in the brain. Heuer and Reisberg discovered that memory for emotional information trends more after immediate recall (Heuer & Reisberg, 1990). Thus, emotional memories could be remembered more often than non-emotional memories.

2.9 Memory Aids and Strategies

Designing memory prosthetics requires focus and a good understanding of how people currently augment their memory with technology and through communication. As I mentioned above, human memory is able to record everything perfectly, but we must then access and recall this stored information.

In general, memory aid could be divided into two categories: internal and external memory aid. The internal memory aid operation does not require any changes to the environment, the only things needed are repetition and the building of associations between words. It is well known in both psychological and common society that repetition can improve one's ability to remember events. On the other hand, external memory aids require the modification of an individual's environment in order to remember specific events. External aids could include written notes, clocks, or the placement of objects in a specific location. Therefore, external memory could be used to support both the retrospective and action slip memory issues mentioned above.

Technology has almost always focused on externally aiding memory through the design of prosthetic devices to cope with memory problems. Wilson et al found that Personal Digital Assistants (PDAs) can successfully provide action cues to support human memory and help people to deal with everyday tasks that may be hindered by memory problems, such as taking a shower or preparing a cup of tea (Wilson et al., 1997). Harris proposed that short cues are usually sufficient to remind users of the task, rather than a detailed description of the action (Harris, 1992). In the past, people have used various memory aids and strategies to help them to remember past experiences. The following sections discuss some of them.

2.9.1 Writing a list strategy

The strategy of writing a list is used to remember events such as weddings, birthdays, or trips. The shopping list is another example, and has probably been around in some form for as long as literacy and paper. It is certainly used often in present-day society. When writing such lists we may use several different methods, but a common method is to brainstorm. Lists can be sorted or categorised while or after they are written. For example, people may list all the items they need and then go back to order or categorise the list. Burack and Lachman stated that using such lists could assist people and

organise their memory to allow them to remember the items in a list, even if the list no longer exists or if they do not have access to it (Burack & Lachman, 1996).

2.9.2 Collaboration strategy

The collaboration strategy is also used to assist people in remembering future actions, aiding both the episodic and prospective memory tasks mentioned above. For instance, one person may ask another questions such as “Please remind me to turn off my mobile phone when the meeting starts”, “Please remind me to close my office when we leave”, or “Please remind me to call my bank this afternoon”. Although this is not a technical solution, it is used very often in everyday life to assist human memory. Bower found that, “when allowed to collaborate, elderly couples who have been married for 40 years or more remember what they read better than young married couples or individuals.” (Bower, 1997). This observation proved that people’s skills could develop with age, and this could be very useful in designing prosthetic memory, because a device that is designed to collaborate with users could augment their memory.

2.9.3 Reminders strategy

People use reminder objects to trigger their memory to remember actions they must carry out in the future. This strategy can be useful for prospective memory. Examples of reminder object are sticky notes placed on the refrigerator or on a computer screen, a watch worn on the opposite hand. Technology has provided several devices to give reminders. The most well known one would be an alarm clock, which is set to remind a person of an event in the future, such as taking medicine, completed cooking time, or that a particular activity needs to start or stop.

2.9.4 Schedules strategy

Schedules are a combination of both the reminder and list strategies mentioned above. The schedules strategy has the advantage of allowing a person to organise the structure of the day and fit activities into time slots. In addition, they can help to categorise the day plan in the individual’s mind. Therefore, repeatedly looking at the schedule throughout the day could help individuals to remember what events have occurred and what their next task is.

2.10 Personal Diary

A diary is the documentation of an individual's day-to-day events, actions, feelings, ideas, and thoughts about people and places, and is intended to keep this information private and secret. A diary is usually arranged by date and has space for individuals to write exactly what happened over the course of the day—who they met, with whom they had lunch, and so on. Therefore, a diary keeps track of details about an individual's day and focuses on daily thought, events, and what is going on around the person.

Scholars have defined a personal diary as a tool for self-discovery. They describe it as a mirror for an individual soul and a place to keep ideas, emotions, and personal secrets. Holly stated that writing a diary can help people to look back over their life experience and support them in remembering events from their past (Holly, 1989). Therefore, by keeping a record of their personal life, people can look back at themselves, their actions, and their feelings to relive past moments and trigger their memory about actions they must carry out in their future, such as visiting a friend or attending someone's birthday party.

DeSalvo introduced three main characteristics of writing a diary (DeSalvo, 1999). The first one is called inner dialog, which is created within the writer's body and the writer's inner world. The second is continuous dialogue, which is created by the writer while writing his or her own past life story. The final characteristic is transformation which accrued within the writer's experience and prospective.

People record their own thoughts and ideas about their personal experience in written form to revisit later. The arrangement of this written material can include a record of what happened over the course of the day by date. The design of a personal diary could be simple or complicated, and differs from one person to another. For instance, a scientist or mathematician's diary could be a timetable, while a poet or romantic person will transfer their feelings into their personal diary. Most people prefer to write their personal diary alone and inside a room as an everyday habit, and often associate their writing with physical objects such as photo albums, a family calendar, personal belongings (necklaces, first shoes, old school books and certificates, drawing, painting), tickets (cinema, theatre, train), bank statements, personal reports, and Christmas cards.

Samuel Pepys is one of the most famous diarists in history. His diary provides a description of life in London and how people lived during the 1660s. He wrote about the Great Plague in 1665 and the Great Fire of London in 1666. Another famous diarist is Virginia Woolf, who started writing her diary in January 1897 when she was fifteen years old. She documented her feelings, her thoughts and the characters of each day of her life (Colayco, 2007).

2.10.1 The benefits of writing and keeping a personal diary

The first and most obvious use for writing and keeping a personal diary is that it assists people in remember their past experiences. Holly described the personal diary as a means of maintaining personal information to look back on (Holly, 1989). He stated that keeping personal notes can help people to examine moments more closely and relive them later. In addition, a personal diary can trigger the human brain to think more deeply. Patsie said that keeping a diary could assist people in looking back and monitoring their activities (Patsie, 1995). She added that writing material down often enables people to know where they need to focus to achieve their personal objectives. Furthermore, a personal diary could assist people in improving their behaviour, actions, and feelings. They could re-examine their written words, looking at them from another angle and dealing with them as though written by somebody else.

Holly said that a personal diary offers a way to index personal demands and emphasise the most important ones (Holly, 1989). Moreover, it could reduce stress and slow down a person's thoughts. Writing could force people to slow their thoughts to the speed at which they write and teach them how to express their thoughts clearly. This means a personal diary can be used as a way to push and encourage people to work harder to achieve their personal goals. For instance, students can use a diary to prepare for their exams by using a schedule to manage their time. I argue that writing diary down could help people to be deeper and more precise and support them in reaching their goals, to keep a record of their personal history, and to reflect on their personal lives. Rainer stated that writing a part of our life routine could reflect on our lives generally (Rainer, 2004).

Therefore, writing and maintain a personal diary could assist people in controlling their tasks and in managing their time and priorities. In addition, it can help people to learn from their mistakes and enhance their productivity. Furthermore, it can be an aid

to people to recall what they did and how they were feeling at a particular place and time.

2.10.2 Journal

The journal is a written record of an individual's ideas, life experience, reflection and observations that is not private. Therefore, it is used to record and examine life experience like a diary but does not necessarily record every day activity. There are many types of journal. A travel journal, for example, is used to document an individual's journey and to keep track of and comment on it. Teachers also often ask students to write a journal and share it with others; the aim is to help students to think creatively and to learn to write down their thoughts and feelings on paper. I argue that writing a personal journal could assist people in exploring their reflective writing, improving their understanding of their life experience, and investigating different dimensions of personal and professional inquiry.

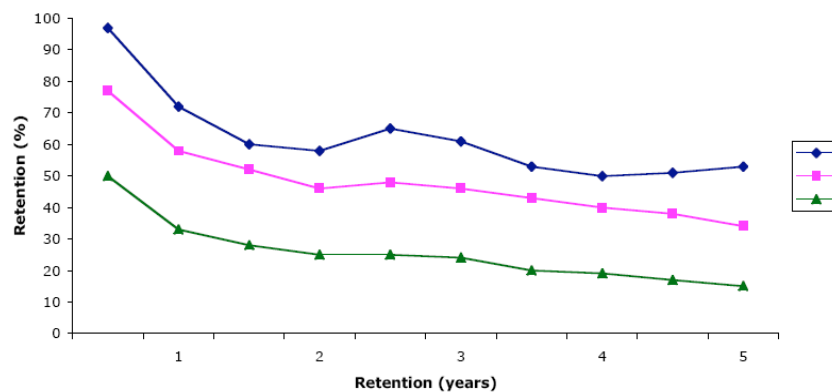


Figure 2.7 Retention curves as a function of the number of retrieval cues (Wagenaar, 1986).

Wagenaar recorded six years of his everyday experience in a written journal (Wagenaar, 1986). He wrote down the time, place name, who was with him, and a brief statement about the event. At the end of the recording period he evaluated his collection of randomly selected episodes and made two significant observations: that recall curve over the first year sharply decreased and then became steady over the next five years, and that using more cues could assist people in remembering information (see figure 2.7).

Therefore, the journal is an effective way of monitoring an individual's growth and can assist people in reaching their goals and reflecting on their internal state. All of these together can enable people to know themselves better and to know more about their environment and their values.

2.10.3 Blog

A blog is often used to digitally record and publicly share thoughts and ideas on specific topics on the Internet. In this class of diary, individuals document their life experience or social comments day-to-day. Some people use their personal blog to keep in touch with family and friends and to share their thoughts and feeling with them.

2.11 Strategies used to trigger human memory

People use many methods and tools to look back over their lifetime and remember and relive past events. There are many reasons for doing this, such as to tell their children, friends, colleagues, or others about interesting moments from their past life, such as their childhood habits and university years.

2.11.1 Photo Albums

Photo albums contain special captured moments and precious moments of family and friends and are therefore often extremely personal. This tool could be valuable in uncovering hidden memories. For example, looking at peoples' faces in the photos could give people hints about things from their past life experience, such as names, dates, places, and events that occurred with that person.

In addition, looking at an inanimate object such as a tree or building in family photo could help people to remember some of their family life and could prompt them to remember more about that time. For instance, *“My brother fell down from that tree and broke his leg ... he was twelve years old ... we lived in this house when I was in the secondary school ...”* Therefore, I argue that photos work very well to augment human memory for remembering past events. In addition, photos are an excellent place to rediscover places and to discover old memories; they could help people to travel back in time and relive the event shown in the photos.

2.11.2 Visiting old places

Visiting a former home, school or club could trigger people's memories of past experiences. Often people think that they can remember details of an event, but when they revisit the place again they find that their information is incomplete or incorrect. Therefore, revisiting an old place could trigger memories of past events even if that place is completely changed or reconstructed. I argue that within the place there are many other factors that could stimuli human memory to remember past events, such as people, food, weather, and the environment of the place (such as the sea, mountains, or desert). Although no such data was captured, I believe that being in the same place again could stimulate human memory and help people to remember details of any events that took place there.

2.11.3 Old books, yearbooks, and newspapers

Old books, newspapers, paintings, or certificates that relate to someone's childhood, former homes, or work are good memory triggers. I argue that individuals can remember the names of schoolmates, teachers and experiences when they look back at their schoolbooks. In addition, news in a newspaper can also assist the human memory in bringing past events to light, and a yearbook that contains a person's signature may also help in remembering past experiences.

2.11.4 Family Calendar

A family calendar (see figure 2.8) is used to make a note of the family's future plans, helping them to remember what they need to do in the coming days or even months.



Figure 2.8 Samples of family calendar

It contains details of their social life, home schedule, and work schedule. People sometimes carry their calendar everywhere with them to use it when they need to register or to remember specific events.

2.12 Reflection

Reflection aims to encourage people to improve their learning and practice, as well as observing their interactions, analysis and judgment. Through reflection, they can think over what happened and how to improve their performance in the future. Jones notes that reflection is a term associated with learning from experience, and acts as a mirror of someone's self image, allowing them to improve and develop their personal life (Jones, 1995). Thus, reflection could be described as an active process of an individual witnessing their own experience in order to take a closer look at their activities, examining their experiences rather than just living them.

Therefore, reflection could help people to learn from their works and from their everyday life experiences when they look back over their logged data. The experiences that they could learn from could range from a presentation they gave or conference they attended to a particular success, a relationship, a disaster, or any other event. Schön stated that reflection occurs when people encounter a unique situation or when they cannot cope with new techniques learned through their formal education (Schön, 1987). Therefore, reflection might include examining patterns of past experiences (such as one's behaviour over time). I believe that reflection involves individuals looking at their past experiences from different angles or perspectives. Thus, the value is not in reliving past events (as in recollecting) but in seeing things anew and framing the past differently.

2.13 Memory Prostheses

Memory prostheses aim to give the computer a greater sense of context by connecting data with context. Many scholars proposed using a computer and adding context to data and events, as this would be useful to trigger a user's memory to remember events even if they were not captured by any devices. Erngrund et al pointed out that memory prostheses are expected to be more useful in augmenting human memory in the near future (Erngrund et al., 1996). Jyrki proposed that creating memory prostheses by using new Personal Digital Assistant (PDA) devices and software would augment individual's

memory in novel ways to remember personal activities (Jyrki, 1999). Lamming et al investigated the design of memory prostheses to augment memory at EuroPARC (Lamming et al., 1994). Their fundamental idea was to collect data about the user's activities in order to generate interactive cues to support people in remembering information and past events. Tulving mentioned that most memory prostheses projects shared the idea that "The physical context can be a powerful cue for recall" (Tulving, 1983). This assumption was based on the fact that people often categorise their past events into episodes. Thus, memory prosthetics could be useful in both working life and free time to improve a user's memory by leveraging their context.

2.13.1 Designing Memory Prostheses

Newman et al proposed a system called PEPYS to capture individuals' movement in order to provide cues to remember past experiences (Newman et al., 1991). Based on these experimental results, Lamming and Flynn developed a new wearable system called "Forget-Me-Not" to capture users' activities, such as phone calls, email exchanges, and/or user's location (Lamming & Flynn, 1994). They offered information about users' actions to allow them to visualise and search for specific events. Eldridge studied the value of using video to aid in the recall of work activities (Eldridge et al., 1992). They found that video could help people to remember the context of memories. Luszcz mentioned that picture memory decreased with age (Luszcz et al, 1997). Harper et al investigated the importance of location information in their system, which was called "active badge system" (Harper et al., 1992). They found that location information could be useful for the design of memory aid systems, and could provide important cues for prosthetic memory. Therefore, creating a lifelong system that is able to capture, track and archive a person's movement through their house could support them to locate their lost objects, such as classes, car keys, or television remote control.

2.14 Distinguish between diary and memory prosthetics

From the previous discussion I can clearly distinguish between writing a diary and lifelogging technology. Some people think of lifelogging as progression from pen and paper to technology and electronic devices. However, lifelogging can mean more than that. In a personal diary, as I mentioned above, people include their feelings, thoughts and ideas in their handwriting. This sometimes affects and changes the image of the event in their mind when they revisit it.

On the other hand, lifelogging tools often capture the surrounding environment as well as any interactions with other people and objects. It tends to be a witness to individuals' events by objectively tracking, capturing, and retaining information about everyday activities. I believe that this could augment human memory and provide flexibility to lifelogging users, freeing their mind to see, examine, and discover new information every time they revisit their lifelogging diary.

2.15 Technology as Memory Aid

There are a wide variety of applications and forms of personal memory management systems to support human memory currently in use, including manual memory capture and simple forms of memory retrieval such as PDAs, talking alarm clocks, voice records and wrist watches (Koblent, 1995). The most common systems are address books and scheduled and emails. Electronic mail (email) is the first tool used as a technological memory aid to help people remember their event by sending messages to their email account. Jovicic mentioned that repeatedly checking an email inbox and seeing a message could enhance human memory performance (Jovicic, 2000).

Personal diaries, such as Calendar-Microsoft Outlook, have become the most common way for people to organise their everyday activities. In addition, there are a large number of host websites to enable individuals to keep a record of their memories on web log entries. For instance, the website Blogger is designed to enable users to create a diary by using email messages (Webhostingreport, 2009). It allows users' to post time-stamped video, audio, or text to their blogs. Flickr is well known as a host website for photos and videos (Flickr, 2012). It is common for users to share and embed their personal photos with a text description to help them in the retrieval process. Mobilblogg is another example of a site that logs audio and video (Mobilblogg, 2012). It allows users to email their memories to their blog from their mobile phone. Facebook is defined as a social network service, but is also used to log photos, video, or text (Facebook, 2012). This software allows users to create a personal profile, adding other users as "friends" in order to share information. Twitter is another well known website that offers a social network and logging service (Twitter, 2012). This service allows users to send and read messages that contain limited text in order to make queries and share information. YouTube is an online public communication web service that allows people to download, upload, view, comment on, and share their video clips with friends

and colleagues (YouTube, 2012). It contains different types of clips: educational, comedy, music, entertainment, action, video blogging, short original video, marketing, and much more. LifeSnapz is another free web service that people use to record and organise significant events, landmarks, and other moments in their lives (LifeSnapz, 2012). Users of LifeSnapz can associate text, photos, and video to express specific events. In addition, they can share them with family, friends, colleagues, schoolmates, or any other group. Furthermore, they can explore these events on a timeline, maps, or lists.

I believe that technology could assist people in remembering past activities by offering effective cues to trigger their memory, allowing them to relive specific events through the step known as “episodic memory”. Remembering and retrieving some aspects of an event could lead to memories of many other aspects of that event. For example, remembering a location could trigger memories of the people who were there. Furthermore, a lifelogging collection could also help people to relive past experiences for emotional or sentimental reasons, such as through watching home videos or looking through photos with friends or family.

2.16 Lifelogging and Memory

Individuals can remember pointless material while sometimes failing to remember someone’s name, someone’s phone number, or where they have put their glasses or car keys. Schacter stated that forgetting is mostly associated with memory functions, and deleting unused or out of date information could be useful for people, but it is impossible to forget or delete the things one does not need any more (Schacter, 2001). Using technology to augment cognitive capacity and support human memory is not in fact a new idea; technology has been utilised since the first written word. Nowadays, digital objects such as small sensors make it possible to store vast amounts of information about users’ environments passively, without their intervention. People can keep enormous quantities of information and are no longer required to be selective. O’Hara et al said that growing use of digital technologies means that many records of conferences, meetings, or communications are in digital form already (O’Hara et al., 2006). Nowadays, individuals can store significant quantities of information about their everyday environment and about themselves. For instance, Gordon Bell and his group estimated that one terabyte of storage would be enough to hold all the books, emails,

music tracks, and photographs that a person is likely to accumulate, as well as the conversations that they are likely to take part in, over sixty years (Bell & Gemmell, 2007). In addition, Alan Dix stated that 70 years of high-quality video recording would require less than 30 terabytes of storage (Dix, 2002); (O'Hara et al., 2006). This technology led to the development of numerous lifelogging tools to support individuals in augmenting their organic memory.

2.17 Summary

In this chapter, I first pointed towards an overview of the human memory structure and process. I reviewed different types of human memory and also focused on how memory systems are organised. I explored how the memory stores and retrieve information. In addition, this chapter introduces and distinguishes between three types of memory problems: retrospective, prospective, and action slips. I explored different strategies that people used in the past to augment their memory, and the benefits of each of them. Furthermore, I improved my understanding of how one successfully and accurately remembers something, and the dependence of this process on the interrelation between encoding and retrieval processes. Moreover, memories are stored, archived, and retrieved by combining information available in the current environment or situation with patterns or cues that have been encoded and stored in the past, and could be initiated by the introduction of cues associated with the memory or by consciously asking questions to aid memory retrieval. I have pointed towards evidence that visual images are valuable cues that will stimulate the memory to remember past actions and events. In addition, I discussed how technology could be used as a memory aid to augment and enhance memory tasks. Furthermore, cued retrieval could help the organic memory remember details better than free recall. All of this motivated me to study and discuss the history of lifelogging technology to improve my understanding of how past systems for processing lifelogging operations—capturing, archiving and retrieval—were designed and built. I believe that this will help me to find and fill the gaps.

Chapter 3

An Overview of Lifelogging

3.1 Introduction

This chapter reviews previous research into lifelogging technology and aims to develop my understanding of its content architecture and composition. The habit of writing a diary is very old and known all over the world. This shows that many people like to retain their everyday life experience for reasons such as remembering events, sharing them with family, friends or other groups, or for use as evidence to prove that particular actions or events took place. However, nowadays, personal activities are often too complicated and diverse to be written in a diary without missing anything. In addition, the capacity of digital storage is sharply increasing compared with its prices. All of this encourages scholars and researchers to design, build, and introduce new devices and systems to make in-depth lifelogging a reality.

The term lifelogging refers to a comprehensive archive of an individual's life experience in digital multimedia format, produced over an entire lifespan by using computing technology for exclusive personal use. It is a self-surveillance system. The main aim of this technology is to record and archive individuals' everyday conversations, actions, and activities in multimedia forms for the purposes of revisiting it in the future and supporting remembrance. It is a step towards the transformation of home computers into efficient memory prosthetics that support and enhance human memory. This could include web pages visited, credit card purchases, phone calls, sent and received emails, scan of faxes and sent and received post, sent and received instant messages, books and magazines read, radio and television selections, GPS location information, and biomedical data captured by wearable sensors. I argue that keeping daily activities and detailed time could dramatically improve individuals' effectiveness, productivity, and style of living. For instance, it could solve issues of time management by showing people how and where they spend their time and could provide an idea of how they might better utilise their time. In addition, allow them to track, criticise, and improve their behaviour.

The most popular form of lifelogging is a recorded description of some part of one's life experience in text form. Nowadays, an individual's experience could include a variety of data types such as text data, visual information (in the form of a video or photo), audio information, biological information (blood pressure, heart rate, skin conductivity, respiration rate, and muscle activity), weather information, current news, location information and more besides. This information would be archived, managed, and controlled by life-loggers themselves. Thus, the user could add, delete, and retrieve information whenever they needed to.

3.2 Lifelogging Goal

Lifelogging has become gradually more familiar to people all over the world. Currently, technology acquisition is growing to be mature enough to digitally and automatically capture a person's life experience in multimedia format. Therefore, monitoring and keeping track of someone's everyday actions and activities would be both easy to do and a widely available option. For instance, Internet browsers keep a record in the browser history of every web page visited by users. In addition, music players can remember the music that users listen to frequently. Furthermore, mobile phones can store a history of incoming, outgoing, and even missed calls, often with complete information for every call including the phone number, caller name, the duration of the call and the time at which it was made or received.

Thus, the main aim of lifelogging systems is to compile a electronic database of the actions, activities, and relationships that a person has engaged in. These systems aim to track, capture and archive individuals' experiences by recording and compiling a vast amount of data about their everyday activities in order to support their retrospective memory, which is for past personal events. Lifelogging technology would provide a detailed record of the past, including every event, every action, every conversation, and every experience in which its user takes part. This action would support human memory and offer specific functions that could help to find lost objects, locate and retrieve details in documents, remember the names of people and places, review discussions in meeting, remember conversations, and remember other past actions or events. Therefore, lifelogging applications attempt to focus on ways of supporting human memory and helping people to look back over their lives and relive, examine, and search through their past actions and events.

3.3 Lifelogging Benefits

Lifelogging technology has two main aspects: the capturing of data and access to that data for retrieval. The former is to record precious moments and personal experience in multimedia forms, rather than producing a conventional diary using pen and paper. The latter focuses on finding methods of accessing and retrieving required information in meaningful ways in order for the lifelogger to achieve various benefits. For instance, the data could be used as a memory aid to trigger people to remember the location of personal items such as eyeglasses or car keys. In addition, it could provide support in remembering names of people and places, and in reviewing conversations and meetings. This could help them both teach and learn new skills. Lifelogging technology could also be used in the improvement of time management, as it provides a good indication of their user's activities. It could be used to retain family history and improve the way this is shared with others by, for example, improving communication between generations and preserving cultural heritage. Lifelogging could also offer a rich and complete archive of play and work habits that would reflect upon the lifelogger themselves. Finally, lifelogging data could serve as a warning system that would help in the diagnosis of illness and in prescribing medication. This is possible because the system could monitor biological information such as blood pressure, heart rate, fetal growth and movement, and a presence or absence of bio-chemicals.

3.4 Lifelogging History

Vannever Bush, director of the United States Office of Scientific Research and Development (OSRD), made the first reference to what is today known as lifelogging during World War II, in his famous article "As We May Think", published in 1945. In his article he introduced the concept of his device "Memex" "a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility" (Bush, 1945) . Bush described his vision of Memex as a tool that could be used to increase people's ability to record, organise, search, and exchange the vast amount of information they encountered on a daily basis, as well as supporting researchers in managing their documents, notes and other information.

Initially, Bush used photography to capture "life records", and then he proposed the idea of a "walnut camera" that was placed on the forehead in order to capture life

moments (see figure 3.1a). After that he introduced his Memex device to support the archiving, searching, and indexing of personal information. The term “Memex” stands for “Memory Extender”. The device consists of a desk that is mostly a piece of furniture at which the user works. On the desk are angled translucent screens, onto which material can be projected for convenient reading. There is a keyboard, as well as sets of buttons and Levers (see figure 3.1b). Memex was an electromechanical tool that was supposed to organise information as a human brain does.

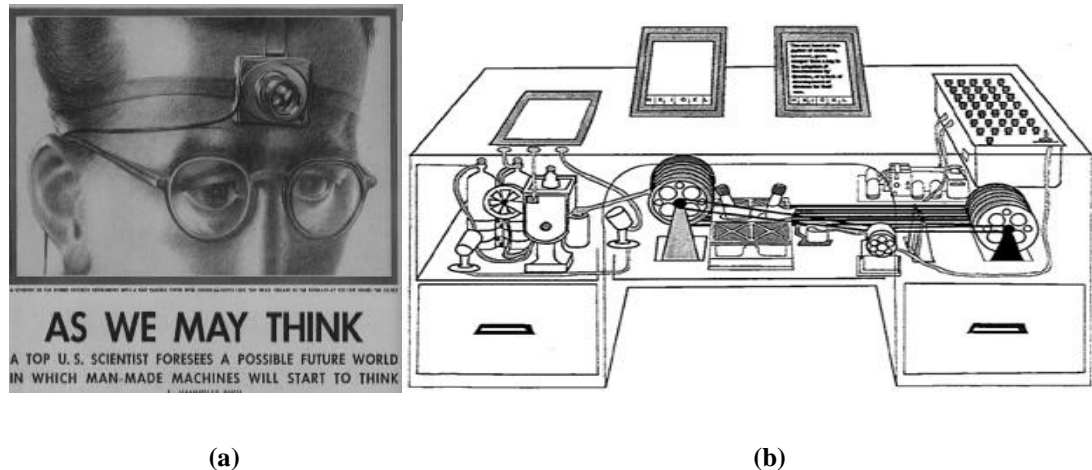


Figure 3.1 Vannever Bush's walnut camera and Memex machine (Yeo, 2007)

Memex was a very early vision of an interactive system that aimed to enhance and augment individuals' memories. The users of this system would be able to easily add new documents and retrieve those they had already seen. In addition, it would enable them to add or follow links and notes created by themselves or by other researchers. Furthermore, besides linking features, Memex was designed to allow users to record new information on microfilm by taking photos from hand-written notes, documents or from a touch-sensitive translucent screen, and to record photographs, voice comments and timestamps while the researchers worked. Bush did not develop the precise technology necessary to achieve this, but he correctly foresaw two of the fundamental features that are used in many applications today: annotation and links.

Lifelogging research can be divided into two main groups: continuous archiving and retrieval of personal experiences, and personal information management. In the following two sections I will provide an overview of some systems for each group.

3.4.1 Continuous Archival and Retrieval of Personal Experiences (CARPE)

This group of systems focuses on systems and methods that are used to passively capture data and retrieve detailed information. One of the earliest systems in this group was created by Douglas Engelbart, who realised the Bush storage idea as a digital technology in the 1960s. Douglas developed a hypermedia Groupware system to support bookmarks, hyperlinks, records of emails and online journal entries. Later on, Ted Nelson kept a personal recording of every conversation he had, regardless of its importance (Nelson, 1999). As far as we are aware, even he has not revisited this archive. Steve Mann, a professor at the University of Toronto, spent a long time exploring the use of a wearable computing camera in his project “EyeTap”. He used electrical digital eyeglasses in order to continuously record video of his experiences so that he could then retrieve and investigate it (Steve Mann & Niedzviecki 2001).



Figure 3.2 The evolution of Steve Mann's Eyetap device
(Steve Mann et al., 2005)

Mann spent a long time investigating wearable computers, in particular wireless cameras, to record his daily experience onto the Internet. He replaced his large helmet camera that he wore in the 1980s with a small device that looked like an ordinary pair of sunglasses in the late 1990s. Mann said that recognising general human activity or special motions as key to automatic annotation. He was also concerned about the social, artistic, and ethical issues surrounding the notion of lifelogging. He modified the physical appearance of his device to avoid hostile reactions (see figure 3.2).

Steve Mann et al later presented the “Cyborglogger” lifelogging project (Steve Mann et al., 2006). They used a mobile phone application to enable the users to capture live

content from their phone's camera and send it to any of their social network sites or personal homepages. The system supported both storing and real-time sharing of both video and images. On the other hand, it did not capture information about location. In addition, the maximum time of recording was relatively limited for the supported devices.

The most well known and comprehensive lifelogging experiment was called “MyLifeBits”, carried out by Microsoft Research and introduced by Gordon Bell in 2001. The MyLifeBits project was one of the first in this area to extend Vannevar Bush’s ideas, attempting to realise the Memex concept by exhaustively capturing and archiving the user’s life in digital format (Bell & Gemmell, 2007). The MyLifeBits system integrates data captured using wearable devices with data collected on the user’s computer and makes it available for later retrieval (Gemmell et al., 2002); (Gemmell et al., 2006). The system is probably the best and longest-running published system in Continuous Archival and Retrieval of Personal Experiences (CARPE). It consists of a large database containing photos, audio, documents, web pages visited, sent and received messages, phone calls, location information, and anything else that could be digitised, stored, and archived to represent an individual’s life experience. MyLifeBits set out to explore the possibilities and challenges that arise from passively collecting as much digital information as possible about an individual’s experience. It offered tools that are needed to compile and archive life experiences digitally, and to support querying, retrieval and search information. For example, the system stores the data in SQL with the support of annotations and clustering. These facilitates allow for several types of retrieval and help users to manage the data and make it available for searching, summarising or just retrieving specific information, such as audio and video recorded by a wearable camera, sent and received emails, digitised versions of documents, digital photos (indexed by time and location), and web pages visited. The results of a query can be visualised with timelines or as a list.

MyLifeBits was designed to enable Bell to organise and search through his database, as well as being proposed as a tool to support people with memory problems (Bell & Gemmell, 2007a) . It had three main focuses: archiving all of an individual’s digital media over their lifetime, allowing queries about that data collection, and visualising the results in the user interface (Gemmell et al., 2005); (Gemmell et al., 2006). Over a number of years, Gordon Bell recorded almost all of his life experiences digitally. He used a small wearable device called “Vicon Revue” to capture images of everything that

he saw and did during the day. He recorded and archived every document he opened, every email he received or sent, every web page he visited, and every conversation he took part in—in other words, any data that could be digitalised and recorded (See Figure 3.3).

The MyLifeBits project was key in discovering what extra tools are important for commercialising lifelogging, including face deduction, voice recognition, speech-to-text software for transcribing or searching phone calls, and search and retrieval capabilities to classify documents (Bell & Gemmell, 2007a).

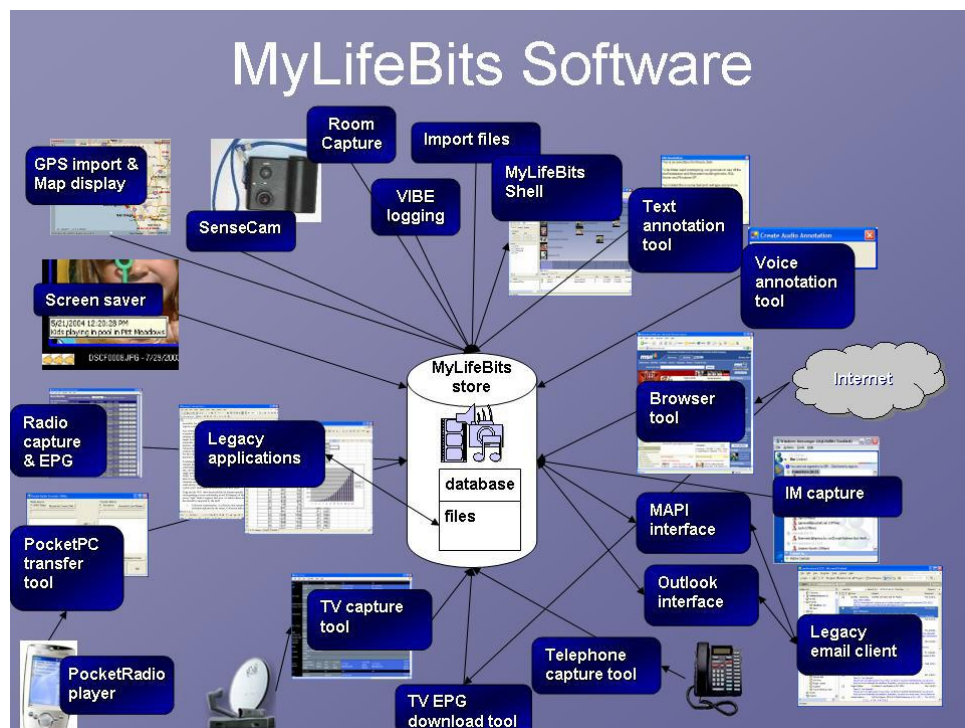


Figure 3.3 The MyLifeBits system (Gemmell et al., 2006)

The MyLifebits system introduced pivoting search within the database, which allowed the user to narrow the results based on the user's input and offered a partial view of the data (Chau et al., 2008). This technique attempted to make a distinction between searching and browsing.

Besides the two lifelogging projects mentioned above, there are a growing number of related projects. For instance, Vemuri and Bender investigated lifelogging through the audio recording of an individual's life (Vemuri & Bender, 2004). They designed and built a user interface that ran on a mobile device to record audio at the user's request.

They could then use an audio-based memory retrieval tool to browse, search, and listen to audio and associated speech-recogniser-generated transcripts.

Once the speech recognition technology has been used to transcribe audio to text, the user can search the transcribed audio and also navigate it using a timeline. When Vemuri and Bender evaluated their system user interface, they found that recognition was not 100% accurate. However, they pointed out that the main goal of the searching process is not necessarily to find specific information, but to enable the user to find cues that are able to trigger their memory and lead to a recollection of the required information. They added that their evaluation of their system gave encouraging results for this approach.

Ellis et al also investigated using audio recordings in their lifelogging experiment (Ellis & Lee, 2004). They continuously recorded audio of their own personal life experiences to assess how such data could be automatically analysed, indexed, and visualised.

Nokia developed multimedia diary software for use with mobile phones, which aimed to help people to automatically organise the photos, videos, messages, and sound clips created on their mobile phones. Data could be organised in a timeline and the diary was searchable via its contents and via automatically and manually created metadata, including time, location, tags, descriptions, file names, and information about senders and recipients (Ward 2004).

Cheng et al proposed a system to record an individual perspective of the world using personal sensors, such as a microphone in a pair of glasses or a camera in a necklace (Chengm et al., 2004).

Harada and Kuniyoshi at the University of Tokyo designed the “Cyber-goggles” system (see Figure 3.4). They developed a smart wearable system to continuously record video of everything the wearer sees. Their system consisted of a pair of glasses with a built-in camera, display screen, and object recognition system to assign names to objects that appear in the video (Pink Tentacle, 2008).



Figure 3.4 The Cyber-goggles image capture (Pink Tentacle, 2008)

Houri and Aizawa et al used a wearable device to record video, as well as data from various sources that could be used to contextualise specific parts of the video (Hori & Aizawa, 2003). They stated that video recording could be used as an aid to support the memory in retrieving past experiences. They pointed out that “... in the case of a conventional written diary, a person can look back on a year at its end by reading the diary, and will soon finish reading the diary and will easily review events in the year. However, watching life-log videos are a critical problem. It would take another year to watch the entire life-log video for one year.” They developed a capture system using a wearable PC notebook that was connected with a wearable camera and microphone to automatically and continuously capture audio and video, along with additional metadata from several sensors (see figure 3.5). In their system they collected context data from various sensors such as a GPS receiver, gyro sensor, accelerometer, and brain wave analyser. They also collected contextual data such as the weather at the user’s location, news headlines, webpages visited, emails sent and received by the users, and documents viewed by the users on their desktop computer. Furthermore, they ran a face detection algorithm on the video to detect the presence of other people and to allow users to annotate scenes in the video by using keywords. They used sensor data to provided functions that enabled users to search or browse to efficiently find a specific part of the recorded video. They also used video retrieval queries in their user interface to search for and retrieve the desired video clips.

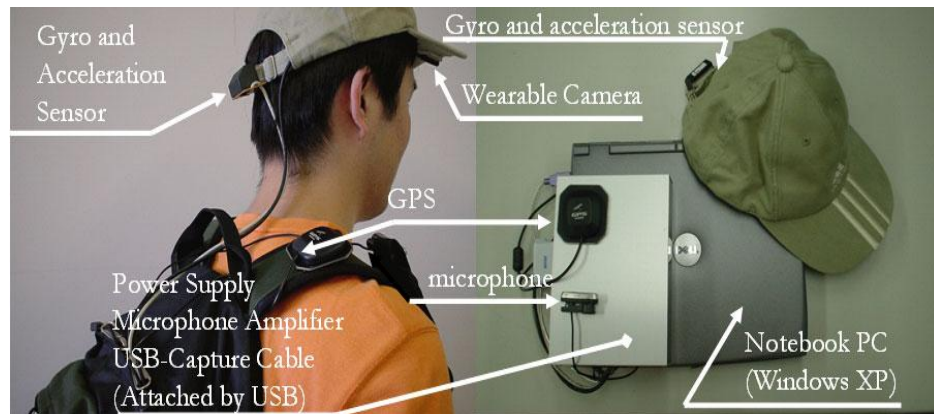


Figure 3.5 Wearable Capture System utilising a video camera and numerous sensors (Hori & Aizawa, 2003)

Aizawa et al stated that context description could be used to index video recording and would be more efficient than retrieving segments of video (Aizawa et al., 2004). They used a number of context descriptions as a key to index recorded video, including location information, orientations, motion, and user interest, in order to facilitate memory retrieval. Aizawa et al acknowledged that retrieval poses the biggest challenge for their system. Their approach employed context-based triggers to record interesting samples of video, such as when the users move or change their directions, speed up, or when a face or conversation is detected.

Rhodes and Starne designed a wearable system for augmented memory called “Remembrance Agent” (RA), which was intended to capture and utilise context in wearable computing and allowed users to write notes while capturing face-to-face conversations (Rhodes & Starner, 1996). They used a one-handed keyboard and a head-up to display, allowing users to focus on their conversation while taking the notes, making it much closer to a true wearable system than Forget-me-not. Rader later developed his system into a wearable form, calling it the “Wearable Remembrance Agent” (Rhodes, 1997). He employs wearable sensors to detect individual’s situations by creating documents that describe aspects of the wearer’s context, such as their physical location, the people that are currently around them, and an automatic time stamp to annotate them. In addition, he used text-based searching to find documents, similar to current search engines Yahoo and Google. Rhodes performed an evaluation to determine the usefulness of using physical context for retrieval (Rhodes, 2003). He found that physical context was useful for retrieval from an archive, since the notes came from one person only.

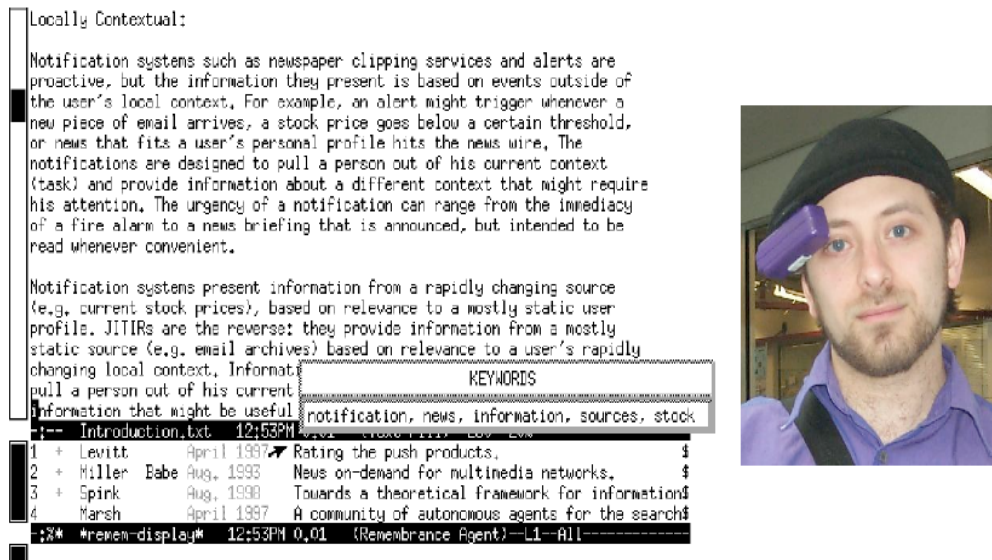


Figure 3.6 The Remembrance Agent user interface (left). Photo of Rhodes wearing the Remembrance Agent (right) (Rhodes, 1997); (Rhodes, 2003).

DeVaul and Pentland introduced a wearable system called “Memory Glasses”, which consisted of a digital camera, microphone, a laptop computer and user interaction peripherals, as well as a track pad and headphones for audio output (DeVaul & Pentland, 2000). In their evaluation, they assert that time and location information could offer great clues about users’ activities. In addition, they pointed out that there is a difficulty in recognising the users’ actions and conditions about their environment, which require more sophisticated sensing and analysis.

Clarkson et al designed and built a semi-automatic system to construct a partial diary of its user’s activities based on sensor data (Clarkson et al., 2001). They called it “Familiar”. The user would wear a video camera, microphone, and accelerometer sensors, which continuously collected data. Machine learning algorithms were used to extract a number of higher-level features from the sensor data; these features were based on the recognition of faces, speech and gestures. Data and extracted information were clustered and segmented into events such as going to work, being at home, and shopping (Clarkson et al., 2001).

The Familiar project does not appear to have had a user interface to retrieve any of the data and extract information; however, I included it in this overview because it is an example of the subfield of Continuous Archival and Retrieval of Personal Experiences (CARPE) that extracts higher-level information from data collected by wearable sensors. This field is sometimes called “Reality Mining”. It is not directly concerned with supporting people’s memories, though the results obtained from such research could

have an impact on data collected by wearable memory aids. However, almost all the projects described above are intended to enhance their user's memory.

Almost all lifelogging systems have two main goals: to capture as much information as possible from personal experience, and to make that information easily accessible. In addition, there are at least two major areas of work in the field of lifelogging: personal experience outside of the workplace and activities inside the workplace. There are numerous techniques proposed in one field that can be used in the other. Moreover, most techniques use wearable devices, and most of them focus on automatic indexing, speech recognition, and the recording of activities. Scholars and researchers found that digital memories could help people to vividly relive an event with sound and images and enhance personal reflection, in the same way that the Internet has aided scientific investigation. Every word one has ever read, whether in an email, an electronic document, or a web-based resource, can be found with just a few keystrokes. I found that most of the Continuous Archival and Retrieval of Personal Experiences (CARPE) systems described above take approaches that vary greatly, though all of them explicitly seek to enhance their users' memory. The evaluation in most cases is limited to investigating the system's functionality and usability, answering questions such as "Can the system do what it intends and promises to do?" and "How easy is the system to use?" Few of them focus on assessing the general desirability and effectiveness for the users. Most evaluations found that automatic capture could be superior to manual capture, and that memory aid systems must necessarily distract from the experience they are recording.

3.4.2 Personal Information Management (PIM)

Jones and Teevan said that "... technology for the management of personal information is concerned with the study and the investigation of people's activities and performance, to acquire, organise, maintain, retrieve, and employ and control the distribution of information for everyday use in order to complete tasks and to fulfil a person's various roles" (Jones & Teevan 2007, p.3). This section describes approaches and systems that mostly deal with the organisation of digital artefacts on a computer by individuals. Most PIM systems aim to support the retrieval of information at the time an individual needs to recall it, while some of them include partial support at the time the user is experiencing something. The systems are grouped into three main categories: systems that re-find information that is already known to the users, systems that take into

account the user's context in some form, and systems that include semantic information about items in the system. In this section I describe a selection of PIM systems that are related to the research described in this thesis.

Dumais studied and investigated a search engine called "Stuff I've Seen" to access and retrieve collections of personal information (Dumais et al., 2003). The system allowed the user to perform textual searches to access personal information such as documents, pictures, emails, calendar items and web pages they had browsed. The results list can be ordered by rank or by date. In addition, timestamps are used to display a timeline view, as well as landmarks that are generated from significant personal events including holidays, appointments in the user's calendar, news and headlines, important world events, and photographs.

Elsweiler et al proposed a system called "PhotoMemory" to manage user's personal photographs (Elsweiler et al., 2005). They pointed out that photographs can provide access to autobiographical memory and could provide richer interactions than text. In addition, photographs could be automatically classified to support the retrieval process. Furthermore, photographs can be grouped and annotated with text-free descriptions and concepts either when photos are added or at the time of their retrieval. PhotoMemory allowed the user to search by using keywords or by specifying different contexts, such as time or location of the photos, or by specifying a combination of contexts.

Ahmed et al proposed a system for personal information management called "SemanticLIFE", which uses semantic annotations for organising the user's content (Ahmed et al., 2004). SemanticLIFE allowed users to use semantic annotations while retrieving information. In addition, users could designate certain photographs as "landmarks" that could help users to find photos taken at around the same time. Furthermore, the location-based view could be used to locate photos according to information about their location. This section reviews PIM evaluations in three main categories: PIM search and re-finding, PIM and context, and semantic PIM.

3.4.2.1 PIM search and re-finding

Systems in this category index personal information and allow users to perform searches of this information by using keywords, similar to the way one uses an Internet search engine. "Stuff I've Seen" is one of the PIM systems that falls into this category. In this type of system, users perform searches of their personal data to find information

that they have previously encountered, which means that both recall and recognition play a role in the re-finding process. Jones investigates users' behaviour around organising and structuring their personal information (Jones & Teevan 2007). He found that the structure, organisation, and reorganisation of such information could help users with goals such as planning tasks and actions, as well as reflect upon their understanding of the information. Teevan et al examined the behaviour of participants when searching their personal information and the web for both new and previously encountered information (Teevan et al., 2004). They identified two distinct strategies that participants use to search: using contextual cues and small steps to navigate and determine how to reach their goal, and using an appropriate query with a web search or desktop to achieve the goal directly.

3.4.2.2 PIM and context

Barreau investigated context types that people could use to access their collection of personal information in order to retrieve electronic documents (Barreau, 1995). She found that participants most often used the location, name, date, or title of their documents to retrieve them.

Ringel et al in their system "Stuff I've Seen" investigated the Memory Landmarks. They examining the value of adding landmarks to a timeline visualisation of search results for email messages (Ringel et al., 2003). They compared participants' retrieval times (timeline and landmark visualisation) with pure "dates only" timeline visualisation. They found that the availability of multiple types of context is useful, and that participants completed the set of tasks significantly faster when the visualisation included landmarks. Elswailer et al observed that participants followed one type of context during retrieval until either they were convinced that they could not complete a given task using this type of context, or they saw a photograph that reminded them of a different type of context to try (Elswailer et al., 2005). This result is consistent with cognitive psychology about the strategies of retrieval. Elswailer et al also investigated the context of email messages and the types that could support people in remembering email details (Elswailer et al., 2011). They found that their study participants remembered a wide range of attributes about an email that they were looking for, such as who sent the message, what the email was about, and why it was sent. In addition, participants remembered information about other recipients and the presence of attachment, images, or links within the message. However, they found that

remembering multiple attributes about an email did not improve the retrieval speed, but in fact slowed down participants when they attempted to re-find the email.

3.5 The Appeal of Lifelogging

The rationale for lifelogging centres on the idea of a “memory for life”, but what is the value of it? Why would people want to record their life experience in multimedia forms? Scholars introduced lifelogging as a form of science and art, a journal, entertainment, and a means for communication between generations (Gemmell et al. 2003); (Kalnikaite et al. 2010); (Sellen et al. 2007). It is felt that lifelogging can improve quality of life. In addition, inheriting the lifelogging of a deceased parent, spouse or child could help to ease the pain of loss and preserve family history (Allen, 2008). Furthermore, lifelogging could reduce crime and might enhance personal security (Allen 2008); there could be a higher chance of catching and thus deterring criminals in a society where lifelogging was widely used. Lifelogging could help to reduce the physical clutter of personal data, as the huge capacity of hard drives today could help to retain vast amounts of different data types such as documents, photos, Christmas cards, audio, video clips and movies. Additionally, lifelogging data could prevent personal data from being damaged by weather and natural disasters. Also, lifelogging could provide a permanent digital memory for users and help them to remember past events, people’s names, conversations, and places they have visited (Kalnikaite et al. 2010); (Sellen & Whittaker 2010). Finally, lifelogging could also provide complete tools to make information searchable and retrievable. All of these together could mean that lifelogging would assist productivity, creativity, physical fitness, and overall wellbeing. Lifelogging could also help to discover talents, potentially leading to the emergence of journalists, entertainers, and communicators (Frigo, 2004). I believe that lifelogging could improve quality of life by offering users a chance to reflect on themselves. For instance, it could increase understanding, confidence and responsibility in personal relationships. In addition, inheriting a lifelogging could help preserve family history and ease the pain of loss. Furthermore, lifelogging could provide a complete system to monitor the user’s body. For example, it could monitor stress levels, arousal levels, fitness, body temperature, blood pressure, and heart rate, as well as providing a dietary program for the user.

3.6 Ethical, Social and Privacy Issues

There are ethical and practical issues concerned with using some lifelogging devices, such as digital cameras and other sensors, in one's personal life. Daniel Ellis encountered shock and resistance from his wife and his acquaintances when he started his project that captured and archived his life experiences through continuous audio recordings (Ellis & Lee, 2004). Other authors have experienced similar reactions (Chengm et al., 2004); (Mann, 2004). Ellis and Lee discussed how these concerns could affect the development of these technologies. In particular, there are political and social concerns surrounding how to capture lifelogging data, how it can be used, and who can use it. Allen said that personal lifelogging should be deemed the property of the person or persons who create it. No one should record or photograph others for the purpose of lifelogging without the permission of the person or their legal guardian. Furthermore, the owner of the lifelogging device should be able to add or delete content at any time. No one should copy or transfer lifelogging to a third party without the permission of its owner (Allen, 2008). I believe that in the near future this resistance and criticism will gradually reduce, and that society will be more willing to accept and adapt to lifelogging. Harper et al suggested that electronic memory may have the same level of impact as mobile phones and the Internet (Harper et al., 2008). All of this will assist scholars and researchers in working out when and where lifelogging is appropriate or inappropriate.

3.7 Security and Surveillance

Nowadays, almost all of our activities and actions are monitored, sensed, or logged by digital technology and electronic devices. Danielson mentioned that there are approximately 4.2 million CCTV cameras in the UK, or one for every 14 people (Danielson, 2002). Lyon pointed out that swipe cards or computer software that is used to record keystrokes or capture phone call history can be used to reward and punish employees (Lyon, 2003). In addition, both workplace and traffic patterns are increasingly being monitored by CCTV cameras, providing detailed information about our movement in and outdoors. Furthermore, some people are willing participants in retail loyalty schemes, thus providing detailed information about their shopping patterns. Therefore, people accept or perhaps ignore such surveillance due to the benefits it can offer. We may feel more secure when we know there is CCTV present, and are more satisfied when our bank statement or phone bill contains all of our details.



Figure 3.7 from SURveillance to versus SOUSveillance: (Mann, 2004)

These sources of information could be linked together, or used for fake purposes. Mann proposed that capturing continuous video and digital images introduces a new element of information that could be characterised as personal “*sousveillance*” (Mann, 2004). SOUSveillance is a combination of two French words: ‘sous’, meaning ‘below’, and ‘veiller’, meaning ‘to watch’. This is opposed to ‘*surveillance*’, meaning ‘to watch from above’ (Mann, 2003); (Mann, 2004). Thus, personal *sousveillance* refers to the act of bringing the cameras down from on high, from being controlled by a higher authority to being used for the personal recording of experiences (see Figure 3.7).

Dodge and Kitchin said that lifelogging has two main dimensions: *sousveillance* and *surveillance* (Dodge & Kitchin, 2007). It is *surveillance* when the data captured is about oneself. Otherwise, it is *sousveillance*, especially when designed to capture other’s data or activities. Mann and Niedzviecki mentioned that *sousveillance* has pros and cons, but for the individual it can be empowering to recall interactions (Mann & Niedzviecki, 2001). From a security perspective, lifelogging can offer great potential to increase an individual’s safety by providing visual evidence of crime. “On the other hand, it could be troublesome for some people especially in public spaces. For example, Steven Mann who has been wearing his “EyeTap Digital Glass” to record his life experience for many years (since the early of 1980s) mentioned that he was in one Paris McDonald’s with his wife and his children to purchase some food when an employee informed them that the cameras are not allowed in the McDonald’s. In addition, another McDonald’s employee approached and angrily tried to pull the EyeTap off of his head when he was with his family having lunch (Piltch 2012). Mann’s story raises serious questions about technology and privacy including where and when we can capture life experiences.

3.8 Visual Diaries

Several studies have been conducted to capture lifelogging data passively with minimal user intervention needed in order to operate the camera. The Vicon Revue “SenseCam” is one example (see figure 3.8). It was invented by Lyndsay Williams in 1999 in conjunction with Microsoft Research Cambridge, UK. It was originally envisioned for use within the domain of digital memory to capture personal life experience, which can be useful as an aid to assist and support people with memory problems, such as those with early Alzheimer’s disease.



Figure 3.8 Gordon Bell of Microsoft Research, wearing a SenseCam Device (SenseCam, 2008)

The camera is a small wearable device worn on a cord around the user’s neck or strapped to their body to passively capture a series of still images as often as once every 30 seconds. It includes a wide-angle fisheye lens to capture almost everything its user sees, as well as multiple embedded sensors to trigger the camera to capture images at the appropriate time. For example, ambient light and an accelerometer trigger the device to capture an image when a user moves or enters a new place, and an infrared sensor is used to trigger it to take one when human body heat is detected in front of the wearer. In a typical day Vicon Revue could capture between 2000 and 3000 images (Wood et al., 2004); (Sellen et al. 2007).

Simon Firth from HP research labs designed the “Photography” project (Firth, 2004). In his project “hesituatese”, he attached a small wearable camera to his eyeglasses to passively capture continuous video of everything that he saw during his day’s activity (see figure 3.9).

Healey and Picard proposed the “StartleCam” project to capture images passively without user intervention (Healey & Picard, 1998). Their proposed project consisted of a wearable computer, digital camera, and a galvanic skin response (GSR) sensor (see Figure 3.10). The sensing system GSR was used to measure the user’s stress or arousal levels, which triggered the camera to capture and save an image when the system detected event that could be of interest to the wearer according to some pre-set specific frequency.



Figure 3.9 Photography project photo (Firth, 2004)

Hori and Aizawa et al. developed a wearable computer system that automatically captured continuous video (Hori & Aizawa, 2003). Their system consisted of a wearable computer and video camera in conjunction with various sensors, including an accelerometer, gyroscope, GPS, and brain wave sensor (see figure 3.5). They adopted one or more sensors to support the retrieval operation. Sasank et al and Joki et al proposed a software framework for use with smartphones to passively capture images and upload them to a server (Joki et al., 2007); (Reddy et al., 2007).

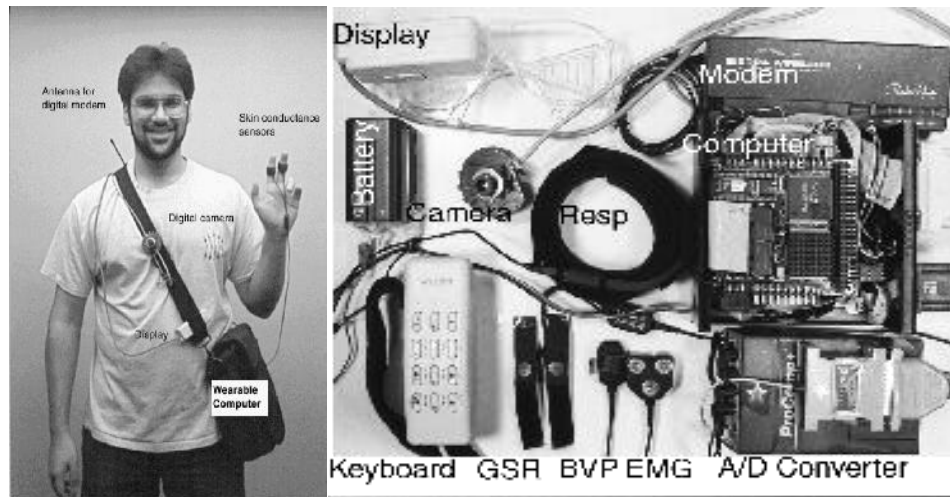


Figure 3.10 StartleCam System (Healey & Picard 1998).

“WayMark” is a similar project proposed by Bukhin and DelGaudio that utilises a mobile phone’s camera as a self-documenting tool to capture continuous images (Bukhin & DelGaudio, 2006). Similarly, Clarkson et al made an effort to identify an individual’s situation by using only a wearable camera and a microphone to record sophisticated data, such as the meetings they attended, the times they entered or left an office, or entered the bus station (Clarkson et al., 2000).

Lamming and Flynn, in their project “Forget-me-not”, developed the first wearable memory aid for workplace-related information. It was called a “ParcTab” and continuously captured user’s activities (Lamming & Flynn, 1994). The ParcTab system was an example of a portable episodic memory retrieval tool, which would record its user’s interactions with people and other devices and store that information in a database for later use, in order to assist the user in remembering activities (see figure 3.11). A prototype implementation ran on PDA-style devices to capture data about its user’s context and make it available for querying using a graphical command language. It was designed to track spatial location and encounters with other people who wore another ParcTab device so that devices can exchange identifying information in an indoor environment by using distributed infrared sensors at the spatial granularity of offices. Lamming et al stated that they designed and built their project to interact with and stimulate autobiographical and episodic memory (Lamming & Flynn, 1994).



**Figure 3.11 Xerox's Forget-me-not wearable device
(Lamming & Flynn 1994)**

They found that this technique improved standard information retrieval capabilities by allowing the use of contextual information, such as the location of a meeting in which a document was accessed.

Thus, using passive devices to capture an individual's life experience provides many advantages. One of them is to assist wearers in retaining their personal data without paying any attention to the devices, and without having to consciously think about recording. The information gathered could reflect on the events and also on the users themselves. On the other hand, the passive recording of digital images raises new problems, particularly related to organising, indexing, and managing the rapidly growing number of images captured. I argue that using content-based image retrieval that uses image content such as colour, shape, and texture is not sufficient for this task for two main reasons: firstly, searching vast amount of images by using their content is time consuming, and secondly, the appearance of more than one result sometimes confuses users, as no information is provided to distinguish between them.

3.9 Technological Challenges

The main technical challenge with lifelogging is how to organise, index, and manage the huge amount of lifelogging data that is accumulated from various passive devices over a long period of time, and how to extract meaningful information from that data and use it as a tool to augment human memory and to improve the individual's quality of life. Another problem relates to the privacy and usability of the data due to both the

nature of data collection and the general public's lack of familiarity with the implications of the technology. For example, Gordon Bell and his team faced many issues in their project MyLifeBits (Bell & Gemmell, 2007). Gordon Bell could not access his data because its format was obsolete. In addition, searching and retrieving audiovisual data is problematic due to the lack of textual annotations.

Another challenge relates to the ever-increasing storage capacity of computers, and the management and organisation of the huge volume of information. Thompson's interview with Gordon Bell in 2006 could give us insight into this problem: "MyLifeBits is now so big that it faces a classic problem of information management: It's hellishly difficult to search, and Bell often finds himself lost in the forest. He hunts for an email but can't lay his hands on it. He gropes for a document, but it eludes him. While eating lunch in San Francisco, he tells me about a Paul Krugman column he liked, so I ask him to show it to me. But it's like pulling teeth: A MyLifeBits search for 'Paul Krugman' produces scores of columns, and Bell can't quite filter out the right one. When I ask him to locate a phone call from one of his colleagues, he hits a bug: He can locate the name of the file, but when he clicks on it the data are AWOL. 'Where the hell is this friggin' phone call?' he mutters to himself, pecking at the keyboard. 'I either get nothing or I get too much!'" (Thompson, 2007). Moreover, I argue that searching for and retrieving a specific clip of video from a vast amount of data about personal experience through traditional means is a huge challenge and is not appropriate for managing lifelogging technology. Aizawa pointed out that, "...the result of capturing human activities is a huge amount of multimedia data. New applications, different from those of traditional multimedia processing of TV and movies, will appear..." (Aizawa, 2007).

Lin and Hauptmann proposed that continuous video must be segmented into manageable units to facilitate the searching and retrieval operation (Lin & Hauptmann 2006). Fitzgibbon and Reiter mentioned that searching for specific images, or audio clip could be possible by using examples rather than text (Fitzgibbon & Reiter 2003). Therefore, searching or browsing a vast archive of multi-modal lifelogging data to find relevant information is a significant challenge. Thus, contextual cues are often suggested as a means of addressing this challenge by shrinking the data collection. I argue that searching for and retrieving digital images or any kind of multimedia just by browsing will be boring, frustrating, and time-consuming for users. In addition, I understand that the challenge is to design and construct a lifelogging prototype that is able to segment lifelogging data into events and to be able to facilitate the searching,

browsing, and retrieval processes, since personal life events are stored as episodes in the human memory. I believe that data captured through lifelogging must be automatically grouped and segmented into distinct events or activities.

3.10 Retrieval Tasks

Retrieval means obtaining specific information from the database by applying queries to it, or finding pieces of information—“indications”, “signs”, “cues” or “stimuli”—that are related to an experience, which could trigger the human memory to retrieve other information related to the same experience. Sellen et al said that cues can trigger people to remember their past life experience (Sellen et al., 2007). They stated that one photo could help individuals to truly remember an event or at least lead them to conclude that it must have taken place. The retrieval process is the second target of lifelogging technology. It aims to access a person’s lifelogging database to obtain significant information related to the specific event or time. In addition, it seeks to make that information meaningful, allowing their users to remember and relive their past actions and events. For instance, when someone wishes to remember details of their eighteenth birthday party, they often use cues such as where the party was, who attended that party, the presents they received, who gave them those presents, or even the food they ate or the music that played.

Ringel et al pointed out that events alone could be useful cues to trigger human memory and successfully retrieve information (Ringel et al., 2003). Lamming and Bhom proposed that details about an experience, such as what it was and when, why, and where it took place, could be used as cues to stimulate human memory to associate that experience with other relevant information (Lamming & Bohm, 2003). Ionescu et al said that images could be useful for spatial navigation (Ionescu et al., 2002). Dumais et al proposed using time and familiar people for memory retrieval (Dumais et al., 2003). Other researchers used time, date and location as context cues to retrieve information (Eldridge et al., 1992); (Tsegaye et al., 2003); (Ig-Jae et al., 2007). Daragh et al adopted both content and context processing (Byrne et al., 2007). Sellen and colleagues used photos to assess recall performance (Sellen et al., 2007). They examined the combination of inference, semantic information, and episodic memory by using personal photos. They found that photos could augment memory performance when retrieving past actions and activities. They noted that this is an interesting advantage of using photos for lifelogging systems. More recently, Kalnikaite et al began to evaluate

the impact of different lifelogging data upon memory (Kalnikaite et al., 2010). They combined photos, maps, and verbal cues to assess the quantity and quality of data collected compared to organic memory (OM). In their experiment, they found that different memory cues could have a different effect on the memory process. They argued that photos could trigger direct recollection of memories and allow people to relive past events through episodic memory. I believe that exploring visual lifelogging data in a meaningful way is a very hard task without using the effective index and without segmenting the vast amount of data into smaller parts to facilitate access and retrieval operation.

3.10.1 Metadata

The main aim of using metadata with visual multimedia is to facilitate accurate access information and to successfully complete the retrieval operation by obtaining a desired item from a vast amount of data. Lifelogging technology has two main processes. The first one is called “capturing data”. In this stage, all metadata is captured and organised to be ready for use in the next step: the retrieval process. Time, date, person, and location data are the most well known types of metadata captured by lifelogging technology. In his experiment Jyrki passively captured images, audio, and GPS with time stamps (Hoisko, 2003). He used date, time and location information as metadata for a successful retrieval operation. Daniel et al proposed the same idea, but they eliminated image capture to reduce data quantity and to save storage capacity, instead proposing that audio data and locations would be enough to trigger users’ memory for retrieval (Ellis & Lee, 2004). Jyrki et al used their metadata to help users to formulate queries depending on time and location information (Hoisko, 2003). Daniel et al allowed users to locate and listen to a specific audio recording depending on its location or on its recording time and date (Ellis & Lee, 2004). They used a calendar to access their logged audio clips. Ig-Jae Kim et al examined extra metadata in their experiment. As well as time, date and location information, they proposed body sensors to give further information about user’s events (Ig-Jae et al., 2007). They found that their proposed metadata could be used to formulate effective queries and help users to browse thumbnail images on a timeline. Figure 3.12 illustrates the metadata that is created from sensor fusion processing.

Aizawa et al used location, weather, news and email, which was automatically associated with date and time (Aizawa et al., 2004). They allowed the addition of more metadata by sending messages from mobile phones to the system via email. The system associated the message with the video based on the time.

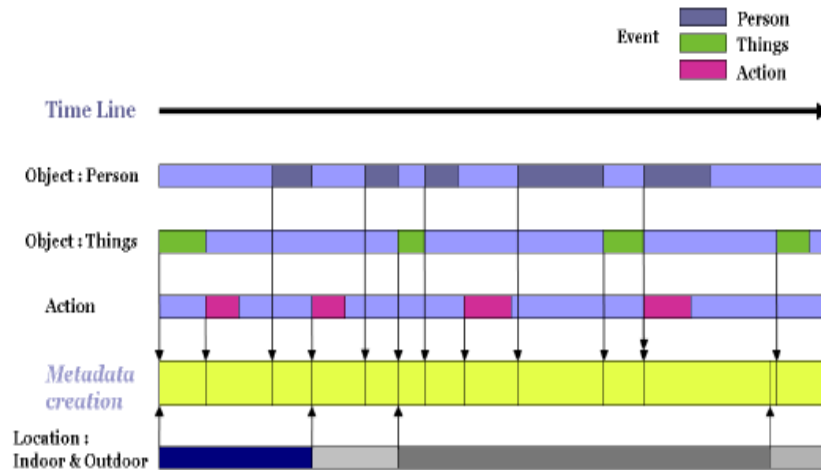


Figure 3.12 Metadata Creation from sensor fusion process(Ig-Jae et al. 2007)

Passively capturing and adding contextual metadata to lifelogging data could augment the organisation of information, facilitate access, and enhance the retrieval process, as well as potentially improve reflection. In addition, metadata would facilitate data navigation and allow users to search by using keywords such as names, location, colours and shapes.

Although metadata assists the retrieval of information in many ways, there are still many problems with using metadata that need to be solved. For instance, inadequate metadata is one reason behind failure to access accurate information. In addition, manually inserting vast amounts of metadata can be costly and requires a lot of effort.

3.10.2 Images Retrieval

Jain pointed out that searching and retrieving digital images from a huge and expanding database would be a hard and time-consuming task (Jain, 1995). The majority of common and traditional methods of digital image retrieval facilitate the searching and retrieval operation by adding extra information, or annotations to the images, such as a description of the image, keywords or both. I believe that annotations can be used to assist the retrieval and searching process. In addition,

manually annotating a vastly increasing database of digital images is hard work, and it is impossible for ordinary people to annotate such huge amounts of data. Using automatic annotation would be the only way to ease the retrieval process. There are two main approaches for images retrieval: text-based image retrieval and content-based image retrieval.

3.10.2.1 Text-Based Image Retrieval

This approach applies traditional text retrieval such as annotation or image descriptions to retrieve a particular image, but this technique has many issues. One major issue is the task of describing the image content. For instance, an image could mean different things to different people or even different things to the same person at different times. In addition, the words used to describe the image content could vary from one person to another. Although new projects have provided enormous electronic storages and proposed many methods to facilitate the retrieval process, the issues become more complicated and complex in managing and indexing digital images. Gemmel et al said that the growing ubiquity of passive capture devices simplifies the logging of personal experience (Gemmell et al., 2004). They said that traditional methods such as a text-based diary could be augmented with other content such as images and video material. Therefore, new approaches and methods are needed to organise, manage, index, and facilitate the retrieval process of vast amounts of images.

3.10.2.2 Content-Based Image Retrieval (CBIR)

The term “content” refers to any information that can be obtained from the image itself. In this approach, an image processing technique is used to extract the low level features of images, such as colour, shape and texture, in order to retrieve relevant images. Chen and others have made many attempts to organise and index digital images into events (Chen et al, 1998). They used colour similarity to cluster and group images. Platt et al. proposed the “PhotoTOC” automatic browser interface to cluster and browse personal digital images (Platt et al., 2002). They used the colour histogram to assist the clustering process. Jaimes et al used both colour and edge in their experiment (Jaimes et al., 2000). Boutell et al used a combination of colour histograms and texture features (Boutell et al., 2004).

There are two facts I need to mention in this section: firstly, retrieving the manually assigned keywords of digital images is absolutely not CBIR, even if the keywords

describe the image content, and secondly, an automatic face detection and face recognition system may use one of two ways mentioned above.

3.11 User Interface

Systems should provide easy and interactive interfaces that permit users to interact with and search for particular information and facilitate access to their data. In addition, they should enable them to navigate through each of the facilities provided by the system. Furthermore, they should offer a convenient multitude of facilities that allow users to interact with their data. Baber et al mentioned that user interfaces should enable individuals to use the interaction skills that they have obtained during their lives, rather than requiring them to learn a new set of commands and interaction techniques with every new prototype and device (Baber et al., 2002). Sebe et al pointed out that emotion is a natural act and is difficult to describe, but should be considered when creating user interfaces (Sebe et al., 2005). Previous lifelogging systems used two types of user interface: graphical retrieval interface and textual retrieval interface.

3.11.1 Graphical retrieval interface

This class of interface allows users to interact with a computer and its control devices to access data information. It presents graphical pictures, icons, or any other special graphics in conjunction with text, labels or text navigation, making it effortless for people to process and represent their information and actions.

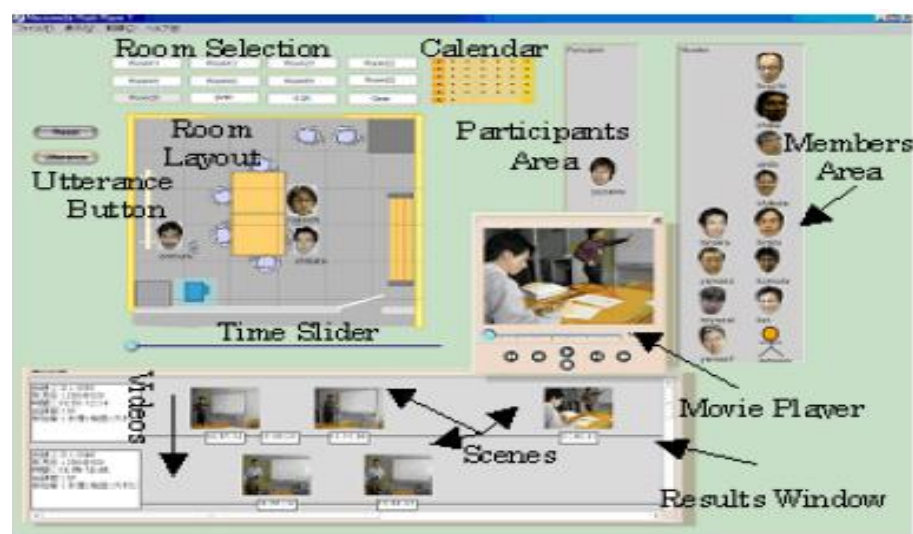
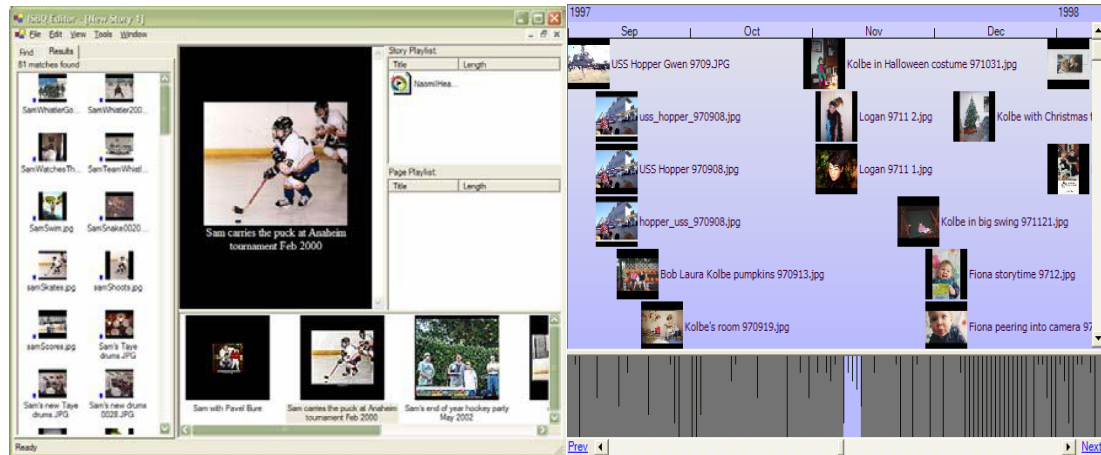


Figure 3.13 Graphical System interface (Takeshi et al, 2004); (Alejandro et al, 2004)

Alejandro et al proposed a graphical system to help users to easily express the cues (Jaimes et al., 2004). In their experiment, they attempted to implement dynamic queries about a specific meeting to allow participants to remember and generate new cues and to support retrieval (see figure 3.13).



(a)

(b)

Figure 3.14 Interactive Story by Query slide show interface and Timeline view of query results (Gemmell et al., 2002)

Kim et al also proposed a graphical interface with query and visualisation capabilities (Ig-Jae et al., 2007). Gemmell et al used a graphical interface with thumbnail view to save the user from having to click to find out whether a collection is empty (Gemmell et al., 2002) (see figure 3.14).

Whittaker et al introduced a graphical user interface for voicemail called “SCANMail” (Whittaker et al., 2002).

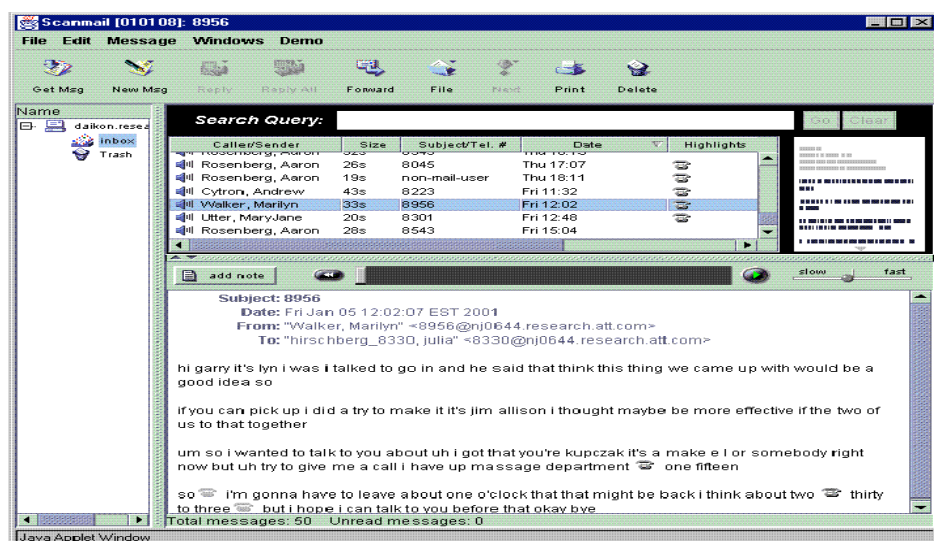


Figure 3.15 SCANMail user interface (Whittaker et al., 2002)

They used automatic speech recognition technology with a large vocabulary to alleviate absent-mindedness (see figure 3.15). The prototype provided the ability to browse, search, and retrieve past voicemail.

3.11.2 Textual Retrieval Interface

I understand that context modelling involves forming a relationship between sensor data and real world knowledge. For instance, Hori and Aizawa formulated dynamic queries, depending on annotations that were obtained from different sensors during the data capture process (Hori & Aizawa, 2003). They used the date and time as the main key for searching for different events such as walking or stopping. They used the town directory to facilitate searching by using the names and addresses of stores or institutions. Video clips were indexed based on voice annotation, key frames or events on the GPS map. Jyrki et al used the time of day and the day of the week to retrieve information (Jyrki et al., 1999). They also relied on their manual annotation and location data, which is determined by time, date, and GPS time stamping. In the MyLifeBits project, data was retrieved by using the metadata, date and time that correlates between images and GPS (Gemmell et al., 2002); (Gemmell et al., 2006). Gemmell et al used time and location to find and browse images and allow for the retelling of events (Gemmell et al., 2004). Furthermore, they used GPS maps to show the images' locations. Melekam et al proposed dynamic queries to support the searching operation (Melekam et al., 2003). They introduced two ways to achieve this: using people and using events. People are used for dynamic searching by selecting from different groups (family, friends, business), and then selecting the person's name. When using events, selected data is used to distinguish between different events and to access the accurate information. Daniel et al used a calendar to access specific audio segmentation and clustering that is tagged with the event class name (Daniel et al., 2004).

3.12 Multimodality

The main goal of all previous lifelogging systems is to trigger and encourage the human memory to retrieve more information about specific events than what the lifelogging device has captured. It is intended that data such as text, speech, images, video, and recorded phone calls will make the human memory remember extra information. For instance, images could tell story about events, triggering our memory to remember the weather from that day, specific smells, and place names. Daniel et al proposed using

only audio data to trigger the human memory to remember events (Daniel et al., 2004). Jyrki proposed using images and audio (Jyrki et al., 1999). Eldridge et al used video, phone calls and workstation activities to trigger people's memories at work (Eldridge et al., 1992). Wang et al used only video in their system; they found that using visual data could help the memory to retrieve information by 0.46, Audio 0.66 and Visual and Audio 0.79 (Wang et al., 2006). Sellen et al proposed using images and location information gathered via GPS to support the retrieval process (Sellen et al., 2010).

3.13 Current lifelogging systems

There are a variety of lifelogging applications on both mobile phones and computers to store, archive, and retrieve users' data. However, at the time of writing this chapter, there is no piece of software available that provides the required functionality (memory capture, memory encoding, and flexible memory retrieval). Individuals need to combine software and hardware to effectively lifelogging. For instance, PIM devices could be used to capture data and encode it into electronic documents. In addition, data should be annotated with text or descriptive metadata to help facilitate the retrieval process.

3.13.1 Audio based lifelogging

Vemuri and Kern proposed using audio data only for lifelogging (Sunil Vemuri et al. 2004); (Kern et al., 2004). Their reasoning was that audio data is easy to capture, cheap, portable, powerful, and efficient. Vermuri used a text-to-speech converter to extract text from audio and used that text in a retrieval process to find specific audio. Kern used a microphone in combination with a PDA to capture audio, and then searched captured audio to identify the speakers. Both of the authors used text annotation to facilitate audio retrieval.

3.13.2 Video and audio based lifelogging

Frigo, Deutscher, and Hoisko used a digital camera and a microphone for capturing memories and used text annotation to retrieve information (Frigo, 2004); (Deutscher et al., 2004); (Hoisko, 2003). Frigo used a PDA for the capture, storage, and retrieval of memories. Deutscher captured memories of the objects he interacted with. Hoisko wore his digital camera to capture video and audio memories.

3.13.3 Lifelogging that includes memory other than video and audio

Aizawa and Gemmel developed lifelogging systems to capture memories alongside audio and video by using additional sensors (Aizawa et al., 2001); (Aizawa et al., 2004) (Gemmell et al., 2005). They captured data from different sensors for two main reasons: to associate data from the sensors (metadata) with the original data (video and audio) to analyse it and make it more valuable for users, and to facilitate the retrieval process. Gemmel and his group, in their well known project MyLifeBits, used a wearable memory device called SensCam, which contained a number of sensors to capture metadata (Gemmell et al., 2005). They aimed to create lifelogging software to help people to capture and keep track of all of their memories, as well as to share their memories with other people.

As I consider the works above, I realise that it is difficult to study and evaluate lifelogging prototypes for many reasons. Firstly, the time of writing this chapter there is no lifelogging device or software that is able efficiently capture, store, and retrieve lifelogging memories. Secondly, in order to study and to assess the usability and the effectiveness of the system, an evaluation needs to run over a long period of time.

3.14 Summary

In this chapter, I explored and highlighted an overview of past lifelogging systems. I also introduced and discussed their benefits and drawbacks. Although lifelogging offers potential benefits to its users, it is still facing many challenges. For instance, it is difficult to manage, search, and retrieve relevant information from the vast amounts of data, which has been noted and discussed by many researches in the community (Aizawa et al., 2001); (Jim Gemmell et al., 2004); (Gemmell et al., 2006); (Tancharoen et al., 2005). Different types of context data have been proposed to facilitate the retrieval operation, such as information about location, people, date, and time.

Lifelogging data needs to be accessible over many decades. Gordon Bell discovered that he could not access files because their format was obsolete (Bell & Gemmell, 2007). File format issues have already caused problems for users as software migrates from one generation to the next, so I must ensure that users are able to open their files long after the systems that originally created and stored them have gone.

Chapter 4

Approach

4.1 Introduction

This chapter presents an overview of the field of Human-Computer Interaction as it applies to the challenge of designing, developing and evaluating lifelogging technologies. I introduce the thesis methodology and contrast the applicability of qualitative and quantitative approaches to the evaluation of such systems, describe the approach I adopt, and justify the methodology and its relevance to both previous and my current research. Moreover, I summarise the most important characteristics of previous research into lifelogging, including the choice and use of participants and approaches to the analysis of such systems. In simple terms, the main goal of this chapter is to provide a clear indication of what I intend to do, how I intend to do it and the reasons for my choice of methodology.

4.2 Human-Computer Interaction (HCI) and Lifelogging

Human-computer Interaction (HCI) seeks to take account of psychology and social science on one hand and computer science and digital technologies, and brings together behavioural scientists, computer scientists, and designers to study the effective augmentation of the capabilities of people using digital technology. Sharp et al noted that HCI focuses on improving the interaction between users and computers by making computers usable and receptive to the user's requirements (Sharp et al., 2007). HCI is also concerned with the methodology and processes relating to the design and development of interfaces and interaction techniques by which information processing can be integrated within both work and everyday activities. Systems need to be designed to reduce obstacles posed by people's cognitive and task models of the activities at hand. HCI researchers study and aim to improve the process of technology development by, for example, developing experiments with new hardware devices, prototyping new software, and developing models and theories of interaction.

The idea of applying HCI to lifelogging technologies that augment human memory dates back to work done by Lamming at Xerox EuroParc (Lamming et al., 1994) and, more recently, the MyLifeBits project (Gemmell et al., 2003), which aimed to capture, archive and retrieve personal experience. In this chapter I aim to review the methods that can be used to investigate and inform the design and assessment of my lifelogging prototypes.

4.3 Designing and Prototyping

Prototypes are an essential and fundamental part of most design processes, particularly those that are user-centred. The main purpose of the prototype is to allow designers to try out ideas, and to involve users in the evaluation of designs with a view to gathering feedback during the design and development stages. In addition, prototypes provide an efficient and effective way to optimise interfaces through discussion, exploration, testing, and ultimately, iterative revision. Prototypes can be iteratively modified and improved until a better understanding of the user interface and the underlying technology has been achieved through the joint efforts of both the designers and the users; as such, prototypes are a key mechanism by which design questions can be answered and choices can be made between different designs. Thus, prototypes can play a variety of roles, as investigations of technical ideas, illustrations of user requirements, or simply the subject of a user evaluation. Dix et al suggested that prototyping processes typically progress in three stages: low-fidelity prototyping, high-fidelity prototyping, and final prototyping (Dix et al., 2003).

- **Low-fidelity prototyping** of user interfaces is concerned with design alternatives such as screen layouts, rather than deeper models that are concerned with user interactions with a system. At this stage one might simply use paper sketches of an interface and drawn illustrations of functionality, which still allow the collection of significant feedback about preliminary design concepts. Rudd et al claimed that low-fidelity prototypes can have great value in the early design process stage of gathering requirements and analysis (Rudd et al., 1996), such as in facilitating brainstorming and encouraging discussion, communicating design concepts and demonstrating interaction. Furthermore, low-fidelity prototypes are sufficient to highlight and identify potential errors (or misconceptions) in both information flow and functionality, allowing the designer and developer to make the most significant improvement in a design before it is committed to code.

- **High-fidelity prototypes** are concerned with functional manipulation, providing a great space to discover and try out the best ideas with target users before making a significant investment. In addition, they force and encourage the designer to think about the usefulness and feasibility of their product much more effectively than paper specs. Furthermore, they provide rich interactions with and clear descriptions of the product to be used as a reference base in both the implementation and test stages.
- **Final prototype.** This stage comes after the pilot evaluation and after feedback is received that will help the designer to finalise the product's functionality and to generate the final version of the prototype. At this stage the prototype is ready for the final testing and evaluation.

Within HCI, a design activity traditionally aims to find appropriate solutions that fit users' tasks and contexts, thereby assisting them in achieving their goals. In broad terms there are two main design stages: conceptual design and physical design. Conceptual design focuses on developing a conceptual model that describes the overriding constructs and components of a prototype and how it will behave. It involves structuring the information space, the creation of alternative solutions, and determining which design concept to pursue. These features could make it easier to passively capture life experience, and allow the assumption that users may spend at least some time annotating captured information. Examples for this type of experience are visiting academic conferences, travel, and scientific fieldwork. Physical design involves the realisation of these concepts through the detailed specification of actual interface components, such as the screen layout, menu structure, and other elements that the user will directly experience (Sharp, Rogers et al., 2007). Haynes et al stated that each design has a rationale to illustrate the reason for using each function in the system (Haynes et al., 2009). They added that the fundamental advantage of this rationale is to help the designer to control, communicate, and explore the pros and cons of the design model during the design stage.

Carroll mentioned that this rationale often concentrates on the psychological issues relating to that product (Carroll, 2000). Sharp et al. illustrated how HCI focuses on systems that can be designed and built to suit people's requirements, and to understand how to integrate both psychology and sociology of human behaviour for computer usage (Sharp et al., 2007). At the design stage, I must identify the tasks in which a system will support people, and then observe different users while they use these tools.

This procedure aims to improve the next iteration of a design. Based on these principles, my second lifelogging prototype was designed based on the first prototype (see chapter six), which itself was grounded in a review of the key elements of memory and remembering what I had gleaned from the psychology literature. I built the initial prototype design based on how a user might visually retrieve a past experience using data captured by available sensors, although exactly which sensors I used was also a key design decision, as was how I integrated this sensor data to cue memories appropriately. In summary, my final design emerged through an iterative design and evaluation process involving real users.

4.3.1 The Design Process

Schacter stated that psychology research could provide a great understanding of the most critical and frequently occurring kinds of human memory problems and enable people to better cope with such issues (Schacter, 2001). In addition, it could help the designers of systems that aimed to support people's memories to concentrate on the areas of true value to the users. Schacter et al and Sellen et al mentioned that instead of capturing everything, lifelogging systems designers would be better off when directing their efforts at the kinds of data that people find most valuable and supportive for their memory (Schacter, 2001); (Sellen et al., 2007). The argument often goes that we should capture as much data as we can because we never know what we might need to remember in the future. Thus, this principle raises two main weaknesses. Firstly, capturing every bit of information related to someone is a very difficult task—nowadays, at least, it is impossible to record absolutely everything of an individual's life experience. For that reason, careful choices must indeed be made when designing and building the system. For instance, capturing different kinds of data requires different sensors and capture devices and these various techniques could add more complexity for both the users and the designers. Secondly, automatically capturing personal information would generate a vast amount of data that could impede the operation to retrieve unique and valuable information from the archive.

I understand that the conceptual design of autobiographical memory systems for augmenting human memory is derived from cognitive psychology research that aims to assist people in retrieving experiences and factual information related to that experience. The retrieval aspects of the design are operationalised in the interactive lifelogging software to visually display lifelogging data and allow users to create interactive cues

that are able to stimulate and trigger their memory. For instance, a lifelogging collection of digital photos and sound could serve as cues to trigger and stimulate the autobiographical memory to retrieve past actions and events, but are not memories in themselves. This fact would encourage the designers of lifelogging systems to focus not on capturing experiences, but instead on generating cues that are able to trigger different types of memories. In addition, a better understand of the cueing process would allow designers to build systems that genuinely provide memory support. Furthermore, psychological literature shows that there are strong connections between autobiographical memories and digital photos.

Many researchers have stated that reflection could be achieved by offering flexible and novel methods for exploring personal data in ways that might surprise, provoke, or educate users (Johns, 1995); (Byrne & Jones, 2009). Brewer mentioned that there is much highly relevant psychology research that has explored in detail how different types of cues, such as place, people, time, and events, could support people and trigger their autobiographical memories (Brewer, 1988). He suggested that places, people, and events are stronger cues than time. Based on this principle, we are better able to determine precise mechanisms by which cues could assist the memory. For example, contextual metadata, such as who wrote a missing document and when it was written, could provide valuable cues to support the retrieval of the lost file. In addition, information in a digital archive may itself serve as a cue to activate forgotten memories, such as when a stored digital photo or email prompts reminiscence about a previously forgotten incident.

Sellen et al mentioned that cues could trigger inferences about what *must* have happened in individual's life, rather than genuine recollection (Sellen et al., 2007). A photo showing a Christmas party with family and friends may cause people to truly remember the event or at least to conclude that they must have been there. This suggests that the interfaces of lifelogging systems should focus on photos as a fundamental element of their design. Thus, there are three main factors that need to be addressed in the design and implementation stage: the context of an experience, semantic information about items in the system and associations between items. Two user studies have evaluated the design and implementation of the lifelogging prototype: the "first prototype" and the "second prototype", seen in chapters five, six, and seven respectively. The first study focused on the system's usability. It showed that the participants could use the first prototype to display, search for and create visual memory

cues to stimulate their memory to remember and answer questions related to their data collection, and revealed a number of usability issues in the prototype's user interface. The second study embodied a novel approach to evaluating systems of this type and tested the ways an improved version of the prototype supported the participants in remembering and reliving their past experiences.

In order to design such a system, I reviewed and studied existing lifelogging systems that were created for people both with and without episodic memory impairments. I believe that incorporating the psychology of human memory into the design of memory systems would open up new possibilities to augment human memory. For instance, better understanding of the relevant psychological process could allow memory system designers to better support the processes. In addition, applying such systems could support reminiscence and reflection. Based on that fact, I used psychology as a foundation on which to base the computer science approach to helping people to remember their past experience.

Many researchers propose guidelines for the design of augmented autobiographical memory (Elsweiler et al., 2007); (Elise et al., 2008); (Sellen & Whittaker, 2010). Their guidelines are based on surveys of cognitive psychology research, which are similar to the survey in this thesis but have partially different results. Hoven and Eggen studied and investigated autobiographical memory; they focused mostly on past experiences and to a lesser degree on related information (Hoven & Eggen, 2008). They concentrated on specific functions of autobiographical memory and the role of physical artefacts, which is reflected strongly in their recommendations. Eggen et al in their study found that very brief textual cues could lead to the biggest amount of retrieved information (Hoven & Eggen, 2009). They made no explicit distinction between remembering types, but their description made it clear that the main aim is to help users to relive their life experience. In addition, they suggested that their approach attempted to provide opportunities for semi-spontaneous recall and to reinforce memories by repetition. Elsweiler et al focused on the area of Personal Information Management and on the information items commonly found in PIM systems, such as photographs, emails, electronic calendars and contact data, as well as other electronic documents (Elsweiler et al., 2007). They focused on memory lapses and the lessons that can be learned from studying everyday memory lapses they showed visual cues to the user during retrieval sessions to facilitate the retrieval of further information. Sellen and Whittaker, in their research into the Continuous Archival and Retrieval of Personal Experiences (CARPE),

focused on retrieval cues rather than capture copies of experiences (Sellen & Whittaker, 2010). Their system sought to aid the strengths of human memory by supporting rather than creating a substitute for it. Their analysis, which was based on cognitive psychology research, found that there were great opportunities for a stronger incorporation of Cognitive Psychology research into autobiographical augmented memory systems in the CARPE area from the starting point of the design process.

Sellen and Whittaker stated that system designs should be based on support type or types of remerging (Sellen & Whittaker, 2010). They added that designers of memory systems should focus on supporting, not supplanting, autobiographical memory, by storing information that can act as cues for the user during the remembering process. In addition, they should distinguish between cues that can be stored in such systems and the actual information to be remembered. Constructed augmented autobiographical memory systems attempt to provide users with the ability to navigate and view the memory items that are stored in the system. They also aim to help them remember an event or related information by providing and displaying cues to stimulate their memory, act as an objective repository of facts to verify their recollection, or assist them in reconstructing an experience according to their goals. In addition, they allow users to engage with the stored memory items and help them to process their natural memories, counteracting the effect of transience.

Context, such as location information, people, and weather, could be used while reconstructing experiences to support the retrieval process; context could enable the user to find all other information items that share context with given information, or find information items using contextual aspects. Elswailer et al and Sellen et al recommended design guidelines using context (Elswailer et al., 2007); (Sellen & Whittaker, 2010).

Semantic memory is used in structuring information and in reconstructing experience to simplify the retrieval process. This type of retrieval relies on similar information being encountered repeatedly. Systems using semantic information could help augment memory by allowing access to information items based on the typical characteristics of the information types and of the relationships between them. Elswailer et al said that augmented memory systems could incorporate associations between experience and facts by allowing arbitrary connections between information items in the system (Elswailer et al., 2007).

Since it was my intention to design an innovative system, I aimed to create new possibilities for people to re-experience moments from the past by using a new design approach. I started the design process by coming up with several ideas and sketches, which functioned as a starting point for the creative process. My conceptual design consisted of three main steps: structuring the information space, creating one or more alternative solutions, and assessing and establishing which design to pursue. Applying these three steps could allow a designer to create the concepts required to build a suitable, complete, and efficient system. Sharp described the conceptual model of a proposed system as a collection of integrated ideas and concepts about what the system could and would do and look like, and how it would behave (Sharp et al., 2007).

Therefore, the first step when designing conceptual models is to create a set of tasks to be supported by that tool.

Sharp mentioned three fundamental questions to consider in a conceptual model:

1. Which interaction mode would best support the consumers' activities?

I used a combination of data and metadata to support and trigger human memory. For instance, in chapter five I discuss the use of CatCam photos, phone call history, location information, emails, and computer activities, and in the second prototype, described in chapter six, I extended the notion of lifelogging to include 3D-accleromter and power consumption, and I used SenseCam instead of CatCam.

2. Is there a suitable interface metaphor to help users understand the tool?

Interface metaphors involve combining users' familiar knowledge with new knowledge to help them to understand the product.

The main goal of the interface metaphor is to help users and provide them with immediate knowledge of how to interact with the user interface.

3. Which interaction paradigm will the tool follow?

Each task the prototype presents has to be separately created in a way that is suitable to the user's setting so that they can capture and recall their information easily. It is necessary to consider effective tools that are able to meet a new generation of demands and have a great impact on the interface styles.

The physical design refers to how the tool will look, what components it will require, and how the screen will be laid out, focusing on elements such as screen layout, icons and menu use. In my thesis I will take into consideration lifelogging devices and infrastructure requirements and what users would expect of these tools.

4.3.2 Evaluation Techniques

In order to understand different aspects and features of a new system, appropriate evaluation needs to be carried out to assess systems and their users' behaviour, impact, and reflection. In Human-Computer Interaction (HCI), there are various aspects that need to be evaluated during all stages of the design process, such as design, implementation, usability, and functionality of the new system tools. Evaluating one or more of these aspects could help users to identify problems, specifically with systems that are designed to augment human memory, and assess how its tools could support specific memory tasks. One of the most popular approaches is called "Cognitive Walkthrough". This approach has been adopted from psychology to evaluate the design of user interfaces in terms of how a designer could identify specific problems in the system, and how well the interface could assist the user in learning new tasks by using psychological principles (Lewis et al., 1990).

Nielsen and Molich proposed another method called "Heuristic Evaluation", which is one of the most informal methods of usability inspection in the field of HCI (Nielsen & Molich, 1990). This method is used to evaluate the usability of software and identify usability problems in the user interface design. The simplicity of heuristic evaluation is beneficial at the early stages of design.

Another form of evaluation is a "Review-Based Evaluation". In this method literature results are used to support or challenge part of a system's design. In this method, all of the user's navigations are tracked and automatically logged, and any qualitative data, verbal and nonverbal, is captured by video during evaluation sessions. After running the tasks, structured feedback is obtained to assess and improve the prototype. I applied all of these methods so that I could introduce a reliable prototype that would support people in achieving their main goals and gaining more than what they expect from the system.

This section overviews methods that can be used to assess supported autobiographical memory systems, and reviews the challenges related to such investigations with descriptions of the strategies used to overcome these challenges in evaluations of similar systems. I consider the evaluation of both Personal Information Management systems (PIMs), as well as systems that are used to support autobiographical memory. The main reason for this is that most of the challenges faced in the evaluations of one system could apply in evaluations of the other. A wider range of evaluation methods has been published for Personal Information Management (PIM) than for any other systems designed to augment autobiographical memory or personal memory, such as CARPE.

Kelly and Teevan stated that the evaluation of PIMs is very difficult (Kelly and Teevan, 2007). They pointed out two main reasons that PIM systems can be hard to investigate. The first is that they deal with a collection of personal information data that completely differs between people. In addition, personal information data could contain a lot of implicit knowledge. Furthermore, sometimes people are reluctant to sign up for evaluations due to concerns about having their memory performance “rated”. The second key reason is that the methods that people follow to deal with their personal information collections might make it difficult to evaluate a new approach.

In their study, Elswailer et al investigated the evaluation challenges of PIM systems (Elswailer et al., 2007). They found that evaluation challenges are related to four main factors, some of which are related to one another. These factors were participants, data collection, tasks, and measure. They pointed out that it is hard to find participants for experiments around PIM systems for two main reasons. Firstly, evaluation methods of PIM systems are not short-term. They require a large amount of time, often taking years, and are not lab-based, as most augmented autobiographical memory systems aim to support the user’s natural memory over long periods of time and thus require naturalistic and longitudinal evaluations. Secondly, evaluation methods of PIM systems require patience and effort from their participants. In addition, using natural data collections such as personal information (emails, photos, call history, or SMS) makes it hard to compare results across participants, and also raises ethical and privacy issues.

One important distinction between PIM systems and augmented autobiographical memory systems is that the information stored in augmented autobiographical memory system is only a part of the whole; in most cases, it is only a cue that can trigger a memory of the experience and the memory itself is not stored in the system. This makes

it even more important to use natural data collections in evaluating the effectiveness of augmented memory systems. Tasks in PIM systems need to be generic enough to allow for participants' idiosyncratic information management behaviour and specific enough to allow for comparison across participants and technology. Measures in PIM systems evaluations need to be chosen with the context of PIM use in mind. In addition, standard measures from the field of information retrieval and recall are difficult to apply in this context because they rely on the availability of clear, relevant judgments and on the knowledge of all potentially retrievable relevant information.

Kelly and Teevan advocated using a mixture of qualitative and quantitative measures in the evaluation of PIM systems (Kelly & Teevan, 2007). They said that evaluations of augmented autobiographical memory systems often force the participants to remember their past, usually by requiring the participant to use the system to answer specific questions about previously captured experiences. This means that all tasks used in these evaluations are artificial to some extent, because they assume that the participant does not remember the requested information and currently wishes to remember it. In addition, time has a much stronger impact on evaluations of augmented autobiographical memory systems than on evaluations of other systems. Most memory failures occur over time and are essentially unpredictable.

Generally, for an evaluation of a system to be naturalistic and longitudinal, it needs to be conducted over a long period of time, as sufficient time needs to pass between an experience and the point at which the participant is asked to remember it to allow them to forget it in the first place. One implication is that task order is extremely important; finding the answer to one task may make it easier to recall or find the answer to other tasks related to the same experience. For the same reason, tasks cannot be repeated within a short timeframe, which rules out straightforward evaluations that require the participant to perform the same task repeatedly using different systems.

There are many methods and strategies that have been used to address the challenges of evaluating PIM systems and systems designed for autobiographical memory systems. First, to overcome challenges related to finding study participants, some studies of PIM systems used the principle researchers as the only participants (example: Rhodes, 2003). However, Sellen and Whittaker pointed out that the results from such an evaluation would be limited (Sellen & Whittaker, 2010). Sellen et al and Kalnikaitė et al proposed

the option of conducting the evaluation over a shorter period of time to lower the restrictions to participants (Sellen et al., 2007); (Kalnikaitė et al., 2010).

Elsweiler et al introduced a laboratory-based approach to address challenges related to data collection and tasks (Elsweiler et al., 2007); (Elsweiler et al., 2008). They combined the advantages of natural collections and personalised tasks with the comparability normally only afforded by using the same set of tasks for all participants. Interested specifically in tasks related to webpage and email re-finding, they first conducted a diary study to capture tasks in this domain as they occurred naturally for their participants. Vemuri et al evaluated iRemember, an audio-based memory aid (Vemuri et al, 2006a); (Vemuri et al., 2006b). They showed how to capture information about experiences without an augmented memory system that can later be transcribed and used to evaluate such a system. Audio recordings of conversations were made between the principal researcher and a small number of study participants over several years. This principle allowed them to create a natural data collection over a long timespan without the challenges associated with deploying a research prototype. Since their research focused on retrieval technology, this phase of their study was conducted without the system under test. These recordings were then fed into the system and used for a second evaluation phase where participants were asked to use iRemember to answer questions about these conversations.

Hoven and Eggen investigated the role of tangible artefacts in triggering memory and re-living experiences (Hoven & Eggen, 2009). They introduced a method for creating experiences that can then be used in a remembering phase. Their study explored which types of cues are most beneficial in evoking recollections independent of any software system. The study used a two phase approach in which participants were exposed in a semi-controlled way to experiences that were thought to create memories: participants visited a theme park and took part in a set of activities that were accompanied by additional stimuli (audio, scent). Participants were later asked to recall activities they experienced at the theme park; the presence and absence of stimuli related to the experience (audio, video, photographs, scents or created artefacts) were used as controls in the experimental setup of the second phase.

With regards to participant selection, it is not uncommon for evaluations to have very few participants, or sometimes even only one, especially in the area of CARPE. In addition, participants are often chosen from groups that have some close connection

with the researchers conducting the study; this makes it easier to ensure that participants do not drop out where long time periods are involved. Data could be collected before a system's development is completed using some other means than the system that is to be tested. This technique could allow for the extension of the timespan between the experience and the participant being asked to remember it.

Based on the findings of this chapter, the decision was made to conduct two user studies of the lifelogging prototypes. The first study evaluated the functionality and the usability of an early version of the lifelogging prototype and its effectiveness in helping people to display, search for, and create visual cues to stimulate their memory, and answer questions related to their past experience. The second study evaluated the effectiveness of an improved version of the first lifelogging prototype.

Three participants were recruited to use the first prototype and two to use the second prototype, to capture different types of data from their life experience continuously for three weeks. They were then asked to answer a number of open-ended questions to assess the success of their memory retrieval. These two studies of the lifelogging prototype are described in the following three chapters.

4.3.3 Processes for Evaluating Tools

Prior to any assessment, it is important to have a working prototype besides having an actual system, to derive a detailed plan for the evaluation process and for experimental design. This technique often requires logging both actions and interaction of the users with the system in real-time as they use it. A tool-focused experimental design might be developed to look at specific aspects of interactive behaviour in a group of users to test hypotheses. The evaluation process for both studies were set up using a lifelogging interface to display visually individual past events and to allow users to create interactive visual cues to augment their memory, which could allow me to automatically log user's answers and other behaviour. I believe that this type of logging is an essential part of a qualitative evaluation, which can offer a great understanding of how people think and behave. In addition, this kind of evaluation enables me to further evaluate, understand, and develop my works. Furthermore, results and information obtained from this method would be clear, essential, and accurate, rather than estimates.

4.4 Methodology

The inexpensive nature of digital video capture and storage means that it is generally the preferred means of data collection in real world settings. Hollan and Hutchins argued that recording interviewees has had a great impact on the practice and scope of behavioural research (Hollan & Hutchins, 2009). Likewise, Ruhleder and Jordan noted how the use of video recordings in the evaluation of participants' activities and behaviour has significantly advanced HCI research (Ruhleder & Jordan, 1997). Direct video of subjects can be augmented with other visual sources. For example, Tang et al used the capture of a computer screen to supplement the traditional video capture of the subject themselves. Tang et al argued that the capture of the computer screen could offer rich data about the actual interaction between users and interfaces (Tang et al., 2006). This approach attempted to study participants' interactions, behaviour, and monitoring in relation to how they used the interface to search, browse, and create visual interactive memory cues to trigger their memory.

My main goal was to understand participants' behaviour as comprehensively as possible: how they use the interface functions, how they manage to retrieve their past actions and events, and the strategies they follow to create their visual cues. Both the studies contained two main phases: passively capturing lifelogging raw data and metadata, and the retrieval of information. In the former, participants were required to employ the proposed lifelogging capture tools to passively collect data from their everyday life experience. The latter evaluated the users' interactions as they used the interface to search, explore, and create their visual cues to support and trigger their memory. Participants were close friends of the researcher and were all familiar with computers and smart phones, but none of them had prior knowledge of the study or past experience of using lifelogging capture tools or lifelogging interfaces.

I believe that close friends and family member would be very confident and trustful to participate in lifelogging research. For example, during collecting their data they will focus on collecting data as much as they can, and will not destroy their data or escape at the end. In addition, in the interviews sessions they will describe their events fluently and they will be excited to describe their events. On the other hand I need to be aware of that, sometime they attempt to satisfy the researcher. In both studies I will focus on how they use the prototypes, how they combine and use their logged data to trigger their memory, and to follow strategies that they use to obtain their target.

In both the studies participants were invited to explain their tasks. They were given the proposed lifelogging devices and a short hands-on tutorial explaining in detail how to use each device. Once they felt confident about using the devices they were invited to participate in the capture stage. Here, I asked them to capture at least ten hours of data a day for three weeks. At the end of each week I visited them at home to upload the data to their personal computers. I extended the timespan between the experience and the triggering of their memories, giving participants two weeks after collecting their data, and then I interviewed them individually for an observation interview. During the interview, I recorded different types of data by using different methods in real-time with the intention of minimising the observe effect. Two software programs were installed into their personal computers to track and record navigations that they performed by using the different interface functions. The first was employed to log and translate their actions into text files to show which data they were focused on and how they associated and linked their data together. The second software was employed to record their computer screen as a video clip. In addition, I used video cameras to record participants' verbal and non-verbal actions and activities. I questioned participants to keep them engaged, and encouraged them to further research their data to retrieve more details about their events. In both studies the qualitative research was applied to investigate the two lifelogging prototypes, with no fixed script for the interviews.

The next sections talk about rationale and approach, study design, interviews, participants, ethical issues, interview procedures, transcriptions of interviews, data analysis, reliability and validity.

4.4.1 Study design

I used in-depth, semi-structured interviews that consisted of two parts. The first was about capturing data and privacy-related issues. The second was about the use of lifelogging interfaces. The interviews were recorded and transcribed and then compiled into tables categorised by the interview questions. Next, the comments were organised by the following repeatedly appearing themes: general experiences of logging, experiences of logged content types, privacy, experiences of logging text messages, sharing of logs, and behaviour changes during the experiment.

4.4.2 Observation

I intended to use one of the most well known qualitative methods of interview, standardised open-ended questions, with interviews being conducted face-to-face. This type of interview is extremely structured in terms of the wording of the questions. Participants are always asked identical questions, while their responses are open-ended. This meant the participants could contribute as much detail as they wished and allowed the researcher to ask probing questions as a means of follow-up. I believe that open-ended interviews allowed participants to fully express their viewpoints and experience, especially when allowed the proper amount of time. In addition, the information provided by participants was rich with qualitative data. Furthermore, the open-ended questions used in this method are designed to obtain in-depth information and encourage full answers using the subjects' own knowledge and feelings. For example, the questions would start with "Why", "Where", "Who", "When", or phrases such as "Tell us about", allowing for an in-depth response. The participants in the two studies took part in the user study individually. I asked them to perform the tasks mentioned in the procedure section. I proposed this number of participants for such reasons as to obtain adequate data and different feedback. In addition, I felt that three weeks of collecting data for each participant would provide me with a great understanding of what data was useful and how it could be used to augment and enhance the memory to retrieve past experience. I explained to the participants that the study had two stages. The first stage would be collecting different types of data from their everyday life environment, and the second stage would be using that data to investigate the study. In the first stage, I showed and informed them in detail how to use each device separately, without telling them in advance about the purpose of the experiment. However, I did inform them that their memory would be tested at the end of the study. I told them that in the second stage I would invite them back for face-to-face interviews, as detailed later on.

4.4.3 Ethical Issues

Lifelogging experiments require researchers to be aware of ethical issues in the case of both the participants' data collected from their everyday life experience, and the data recorded during the interviews such as video, photos, audio, or questionnaires. In both studies I solved the first issues by uploading participants' data to their personal computers and protected by password. For the ethical issues with the interview, I

provided, explained, and signed “Participant Consent Forms” that showed participants that their information would not be used for any purpose other than the study, and that individual people would not be named (see appendix A). In addition, I asked their permission to use pictures and video of recorded interviews at public presentations and conferences. Furthermore, I also told them that it was my responsibility to protect their privacy and protect them from harm, and clarified for them that they were not required to answer any questions that they felt uncomfortable with, to allow them as much opportunity as possible to avoid disclosing information.

4.4.4 Interview Procedure

My main goal in both studies was to obtain insight into the subjects’ experience of the lifelogging interfaces. To achieve these goals, users individually interviewed twice during each prototype experiment. Each experiment contained two main stages. In the first stage, participants were asked to use their devices to capture and collect data from their everyday environment over a period of three weeks and for an average of ten hours a day. In the first study I asked them to use passively use a digital camera to collect photos and a mobile phone to capture GPS location information. In the second study, as well as the previous devices, I asked them to use accelerometers to capture the movements of their body and hands and the movements of some objects from their environment. I also used the electricity power meter to capture the electricity consumption of some of their devices. Furthermore, I informed them about other data that is captured automatically, such as phone calls, sent and received SMS, and opened and sent emails.

After two weeks I invited each participant to attend a face-to-face interview at Culture Lab at Newcastle University. The interviews lasted approximately 90 minutes. The interview had two main aims. Firstly, I aimed to improve my understanding of capture practices by asking questions about the usability of the lifelogging capture tools. In addition, I asked them about their reaction, their family reaction, and the reaction of people in public places. The second aim concentrated on the prototype: I asked questions such as, “How easy is it to use?”, “Did the prototype satisfied your needs?”, “Did you find it useful and helpful?”, and “Did you find what you expected?” In the interview sessions I used two main ethnographic techniques: observation and long interview. With each participant I applied open-ended questions, asking them about events and actions that happened while collecting their data. With regards to security

and privacy, I asked the interviewees' permission to record the whole interview in three different ways for later observation and analysis. I used SnagIt software to record continuous computer screen, my motivation being to monitor, track, and follow participants' navigation between their data, as well as give me a clear picture of how they used the interface to create their cues. I used a video camera to capture participants' faces so that I could observe and understand their verbal and nonverbal action. I also monitored and tracked their hand, body and leg movements. Each movement meant something specific when I linked and collected all of the data together. Finally, "capture-screen" software employed to capture participants' computer screens each five minutes to be used as bookmarks to follow the participants' interactions with the prototype. I argue that this method helped me to monitor the participants' reflection and assess the prototype's productivity and usability.

4.4.5 Transcription of interviews

I understood that using different methods to record face-to-face interviews could generate rich data to assess and understand what was going on during the interview by capturing each verbal and non-verbal action and the exchange between the interviewers and participants. In addition, transcribing all participants' reflections, and systematically analysing them would provide a clear picture of the productivity and usability of the prototype, and would allow me to examine interaction patterns, judged importance, emotional reaction and overall benefits. All sounds uttered by the participants, including laughter or sounds such as "mmm" or "yeah" were transcribed. Participants' movements and body language were monitored, tracked and transcribed as well. I believed that each movement would mean something in particular when I linked and collected all of that data together. In addition, categorising such transcripts would allow me to generate themes by classifying all participants' transcripts. In order to write transcripts I played the recorded video of the interviews repeatedly. I then read the transcripts in order to identify and create themes, which were noted, given temporary titles, and then added to demonstrative quotes from participants as shown in figure (4.1).

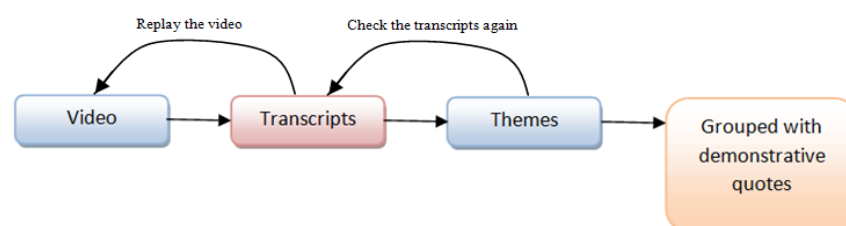


Figure 4.1 Phases of transcripts video into themes

4.4.6 Data Analysis

The nature of collected data could assist us in selecting and applying appropriate methods of analysis. For example, before applying any statistical operation, sometimes a simple look at the data could be sufficient to explore whether there are any patterns. Generally, there are two types of research that could be used with lifelogging technology: quantitative and qualitative. The former research was utilised to investigate things that can be observed and measured in some way. By “measure”, I mean noting how often or how many people behave in a certain way, but without asking the question of why they are doing it. I am more concerned with questions such as how many people exhibit that behaviour, how often, and to what extent. The later research was interested in studying human behaviour, experience such as thoughts, emotions, attitudes, and motivation, and the perspective regarding these. The main goal of this method is to explain social phenomena by considering the social aspects as they occur naturally and to bring out individual differences as well as commonalities among research participants. In this class of research, data is collected in the form of words or pictures rather than numbers, collecting evidence and producing findings that were not determined in advance to assist people in understanding and finding answers for questions about how events could help people to retrieve information, how people formulate their opinions and thoughts, and how people behave and perform when it comes to different actions. I believe that this method could help me to understand and produce answers to my research questions, and produce specific information about the values, opinions, and behaviour of lifeloggers themselves. I used qualitative research to monitor as closely as possible the understanding, interpretation and experience of the rich source of data created by ordinary people from their everyday lives and environment. This could help me to better understand how, why, and under what conditions lifelogging technology could be affected. I argue that qualitative research, which is concerned with opinion, experiences and feeling, could provide a wealth of detailed information and evidence to help make decisions in the research topic. In addition, it could allow for large-scale measurement of ideas, motivations, wishes, desires, problems, behaviour, beliefs, and attitudes.

Qualitative research has three main methodology strategies to collect data: individual interviews (in-depth or open-ended interviews), focus groups, and direct observation recorded by writing documents (Williams, 2007). In this PhD thesis I used in-depth interviews and open-ended questions with individuals to investigate the methodology, to

look at interaction between experimental variables in a natural setting, to understand individuals' interpretations and what people perceive to be, and to generate more in-depth and comprehensive information to describe the context or natural setting of the variables, as well as the interactions of different variables in context.

Regardless of the thesis aims, nature of the interview, and the value of the results, it is essential to use a qualitative method to analyse collected data to provide important details that cannot be determined by a quantitative method that uses numbers. In addition, qualitative observation methods can provide rich data and generate hypotheses for new studies.

Another common and famous observational technique is “think aloud”. Olson said that the think-aloud technique could assess higher-level thinking processes, which are used to examine participants' differences when performing the same tasks (Olson et al., 1984). The think aloud method involves asking participants to talk aloud as they are performing tasks to describe and explain what they are doing and why they are doing it at each stage. Participants' actions would be recorded using audiotapes, video, computer logging, or participants' notes on pen and paper. This method is simple and requires little experience to carry out. I believe that such a technique can provide useful and powerful insight into participants' strategies, and can demonstrate how the prototype is actually being used.

Another approach can be to use “Cooperative Evaluation”. This method is similar to “think aloud”, but in addition participants can ask their evaluator questions, which could encourage them to see themselves as a collaborator in the evaluation rather than just a subject, as they can give their estimation and criticise the prototype as well (Monk, Wright et al., 1993). I believe that making participants think aloud could help the evaluator to ask different questions such as “Why, what, how, where, when ...”, which allows the participants to give their evaluator an explanation if any problems arise. The “Post-task walkthrough” approach involves transcripts being played back to participants for comments (Dix, Finley et al., 2003). This could be done immediately after the interview session to identify reasons for actions. The “Protocol analysis” approach focuses on participants' comments and observation after the experiment is complete (Austin & Delaney, 1998). In both studies on observational methods asks the participants to think aloud and uses a comprehensive protocol to record participants' verbal and nonverbal actions for later use in the analysis stage, in particular through use

of video, SnagIt, capturing the computer screen every five seconds, and logging keystrokes to monitor and track participants behaviour and actions. I believe that this method would allow me to generate data that could be as valuable as quantitative data.

4.4.7 Reliability and Validity

I followed the following procedure to ensure the reliability and validity of the analysis: first, I compared independent analysis of a selection of the transcripts to ensure the credibility of the analysis, and then I checked on the validity through member validation. Smith mentioned that there are two suggested criteria to assess the validity and reliability of qualitative research: internal coherence and presentation of evidence (Smith, 1996). The former refers to whether the argument presented within a study is internally consistent and supported by the data. The latter refers to the publication of sufficient quotations from participants' discourse to enable readers to evaluate the interpretation. I argue that themes generated by this method could offer values maintained by participants' actual dialogue and both reliability and validity of the interpretation can be assessed by the reader.

4.5 Summary

In this chapter I introduced Human-Computer Interaction and the idea of applying HCI to lifelogging technologies. In addition, I described the thesis methodology and introduced evidence of using a qualitative evaluation instead of a quantitative evaluation. Furthermore, I explored the different approaches that I used and presented the reasons for why these were appropriate methods to address the research questions and to show how the study related to previous research. I also summarised the most important characteristics of the study, such as participants, analysis, and finding.

Chapter Five

First Prototype

5.1 Introduction

An increase in the amount of storage capacity available is encouraging people to store and archive their life experience in multimedia formats. I believe that such an amount data will remain inadequate without the use of powerful retrieval techniques to help people access and locate every single bit of their data collection.

In this chapter I describe the design and building of a new lifelogging software prototype to explore different types of personal data visually on interactive user interfaces. The prototype seeks not only to access and link captured data, but to explore that data in a meaningful way that aspires to support the lifelogger in reliving their past life experience. In addition, it is hoped this software will support the remembrance of different aspects of memory that cannot be captured by a device, such as feelings and emotions, by using lifelogging data to stimulate and encourage different parts of memory. This chapter also introduces a new method to study and assess usability, power, and the productivity of lifelogging technology and I will use the first and the second prototype as an example of this.

The main aim of this chapter is to improve my understanding of how different types of data and metadata could support people to generate effective visual cues that are able to trigger and augment their memory of their past actions and events. In addition, my both studies monitored and investigated individuals' behaviours and strategies while they used the prototype. The rationale for this was to be aware of the methods they utilized to create their memory cues. Furthermore, I explored interaction design for lifelogging interfaces, as well as examined how people could use the system in practice. Moreover, I investigated usability issues with the first prototype and how people could use it to answer different questions about their past life experience, which were resolved before conducting a second prototype interface described in the next chapter.

In this chapter I will extend the notion of lifelogging to include: digital photos, location information, sent and opened emails, activities on the computer, phone call history, and short sent and received messages (SMS).

5.2 Lifelogging design

Lifelogging technology in general contains two main complex integrated stages. The first stage focuses on how to capture and collect valuable digital data and metadata that could be used as landmarks for retrieval operations. The second is how to design and build an integrated user interface that is able to explore the collected data visually. In addition, this interface should allow users to search and access the data easily and support them to create valuable integrated visual cues. The main goal of this is to stimulate, support and augment user's retrospective memory; to remember their past actions and life experiences.

There are a variety of ways that psychological theory can inform the design of lifelogging technologies with respect to different memory cues such as: time, place, people and events to trigger autobiographical memories. Many researchers have examined different tools for lifelogging. For instance, Conway pointed out that, visual images could augment human memory (Conway, 2009). Frohlich et al observed that, family photos could support reminiscence (Frohlich et al, 2002). Petrelli et al and Sellen et al proposed that combining location information with visual images could assist people to remember their past events and actions (Petrelli et al, 2008); (Sellen & Whittaker, 2010).

Many researchers pointed out that electronic mail was the first digital memory aid that was used to support people in retrieving their past life experience. They pointed out that people tend to send messages to their own email account to remind them to do things. For example, appointments, renew car insurance, pay bills, attend someone's birthday or even to buy a mother's day gift. The main reason for the use of email is people repeatedly check their email Inbox and will see the message frequently. This activity could enhance their memory performance to remember not only their past actions and events, but their future plan as well.

Nokia mobile phone and others store a history of all calls: incoming, outgoing, and missed calls with details such as phone number, caller name, and duration of each call with a time stamp. I believe that this record of phone calls could not only support people to remember their past phone calls, but it could also trigger the remembrance of more details about that phone call which are not captured by the device. For instance, knowing the caller's name and the time of the call could support people to remember not only the conversation, but their feelings and emotional state at that time. Eldridge et

al in their study “forget-me-not” found that phone calls could trigger human memory in the workplace to remember different activities (Eldridge et al., 1992). Gordon Bell, principal researcher at Microsoft research, in his project MyLifeBits has digitally archived his phone calls alongside many other records of his everyday life such as digital photos, conversations, articles, and home video (Bell & Gemmell, 2007). Bisht et al linked their collected emails, documents, SMS and phone calls to their Computer and Google Calendar (Bisht et al., 2007). They found that SMS and phone calls could support people to remember past activities and actions. Additionally, the MyLifeBits system recorded computer activity collection by storing every single webpage that was visited and any application that was opened by the user.

I believe that the collection of digital data such (photos, phone calls, emails, location information, and computer activities) could serve as cues to trigger and assist retrospective memory about events and how people spent their time as well as to support them to remember actions and events they performed on their personal computers. In addition, improve my understanding to address the precise mechanisms by which cues could support memory. For instance, metadata could support cue retrieval of one photo by providing contextual information about it such as the date, time and place the photo is taken. Similarly, metadata could offer cued retrieval of phone call conversation by providing contextual information about the date, time, caller name or phone number, or place.

In this chapter I intend to investigate these issues by asking three participants to capture data from their everyday life for a three week period. I asked them to capture digital photos and location information. Also, information that is typically already automatically captured by devices, without a user’s intervention, was harnessed. For example, their cell phones record of each phone call they performed including incoming, outgoing, and missing calls (“*call history*”), and sent and received messages (“*messages*”). Furthermore, I notified them that I would use “email-archive” software to store every single sent and opened email and “capture-screen” software to take a picture of their computer screen every five seconds when they move the mouse or strike their computer keys. I explained that all their data would be uploaded and stored in their personal computer and linked together to test usability of the lifelogging interface and how they use the prototype to answer some questions about their life experience.

5.3 First prototype Design

At the very beginning I focused on the following research questions: what data do we need to capture? why do we need to capture this data?, and how do we capture it? And then I started to design and build the user interface. Finally, I tested the interface by asking the participants to investigate their data using the interface as I tracked and monitored how the participants used the interface functions to create visual cues and how they could link their cues together to retrieve their past action and activities.

5.3.1 Capture Tools

This section shows the cornerstones and backbone of lifelogging technology; the capture and archiving of data and metadata. The main aim of this section is to illustrate what data and metadata the prototype intends to capture and how. In addition, I introduce the lifelogging devices that the prototype uses to collect the proposed data and illustrates the reasons behind selecting each of them. The prototype employs three devices to collect data and metadata in both indoor and outdoor activities (see figure 5.1).

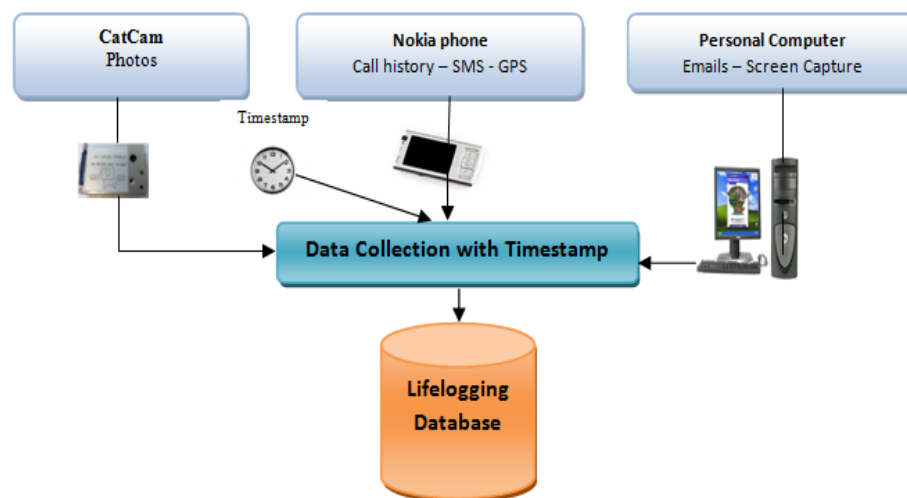


Figure 5.1 First prototype capture devices

The first device called CatCam is used to capture digital photos, the next section discusses its main features and the rationale for using it (Yonezawa et al., 2009). A Nokia cell phone was used in this prototype to capture three different types of data: location information, call history (incoming, outgoing, and missing calls), and sent and received short instant messages (SMS).

Finally, I used personal computers to passively capture and archive the computer screen every five second, as well as to keep a copy of every email sent or opened.

There are three main reasons for using the CatCam camera, cell phone and personal computer. First, I believe that these devices could capture and provide rich data and metadata that people can use and rely upon to trigger and augment their memory in a simple way. Second, using familiar devices, which have the ability to capture more than one type of data passively, would assist people in behaving naturally during the data collection period. Finally, novel information could be generated by integrating all the collected data together. For instance, when we link photo(s) with location information, we would obtain the place the photo(s) were taken. In addition, combining such data with phone call data could tell us more information about the place and sometimes the conversation itself. The following table shows the output of each device that is used in the first prototype.

Device	Capture	Metadata
CatCam	Photos.	Date, time, and GPS - location information data.
Nokia cell Phone	Call history: Incoming-calls, Outgoing calls, and Missing calls.	Date, time, and GPS - location information data.
	Short messages: Received and Sent.	Date, time, and GPS - location information data.
PC computer	Take a copy of each opened emails and capture PC screen every five seconds.	Date and time.

Table 5.1 First prototype devices and their different types of output

As shown in Table 5.1 date and time data could be used to link more than one type of the collected data together and generate new information. In addition, GPS (location information) could be used to distinguish between indoor and outdoor activities.

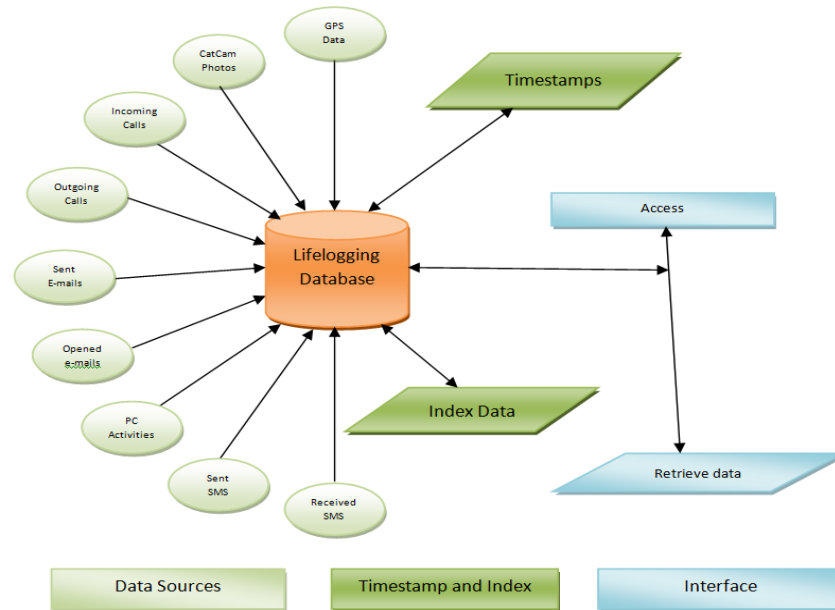


Figure 5.2 Lifelogging connections of data and metadata.

5.3.1.1 Photographs – CatCam

I argue that digital photos could augment human memory and support people to create effective cues to trigger their memory to remember and retrieve their past activities. For example, one childhood photo could prompt the memory of a past life experience and encourage the individual tell a related story even if the contents of that photo does not offer any details. One of the most famous devices used to collect digital photos for lifelogging is called Vicon Revue (the device was introduced in detail in the previous chapter).



Figure 5.3 the CatCam Camera.

It is a wearable electronic device combining a digital camera with a number of built-in sensors such as accelerometer, temperature, and infrared sensors. In this prototype study I did not use Vicon Revue device for two main reasons. First, Vicon Revue was not

lifetime and memory storage. CatCam camera could be set into one of three types of resolution (low, normal, or height). Figure 5.4 shows a sample of photos captured by CatCam at low resolution mode. The battery lifetime depends on the time interval of capturing photos.

For instance, one battery could be enough for five hours when the camera is set to capture a photo every 10 seconds. On the other hand, the camera stops capturing photos without any warning when the battery becomes flat or the memory card becomes full. In addition, we cannot set the date and time of the device. This means the photos do not have a timestamp, an essential marker to enable the photos to be associated with other data that has been captured at the same date and time.

5.3.1.2 Location data - Smartphone and custom software

Petrelli et al and Sellen et al proposed that combining location information with visual images could help people to remember their past events and actions (Petrelli et al., 2008); (Sellen & Whittaker, 2010). Eldridge et al in their study “forget-me-not” found that phone calls could trigger human memory at work to remember different activities (Lamming & Flynn, 1994). Bisht et al linked their collected emails, documents, SMSs and phone calls to their Computer and Google Calendar (Bisht et al., 2007). They found that SMSs and phone calls could support people in remembering their past actions and activities.

A Smartphone captures GPS data, received and sent SMSs, and call history. There are many devices that capture location information data but I used a Smartphone for two main reasons. First, I do not want to distribute lifelogger across many devices. Secondly, cell phones are perceived to be an essential item for the majority of people and are carried almost everywhere. In addition, the GPS allows data to be crudely tagged as either being captured outdoors when there is GPS signal or indoors when there is no signal.

5.3.1.3 Screen and email capture – Custom software

MyLifeBits is the only known project which is concerned with computer activity, specifically the collection and storage of every web page that is visited and any applications that are opened by their users (Gemmell et al., 2006). The fact that computer screens display the actions and activities performed by users on their computers allowed me to develop a software program which can log a screenprint every

five seconds. A screenshot is taken only when the user has moved the mouse or used their keyboard. This helped improve storage capacity by reducing the capturing of redundant data. Taking a screenshot, rather than storing the files that are open, avoids the problems that handling multiple different software programs and their associated file types brings. In addition, after a period of time, it might not be possible to open some file types as a result of changing the application format. Similarly, simply recording internet browser history was not satisfactory as we were unable to access some web pages visited by the users due to the pages moving to a different address, being reconstructed, or not existing anymore.

Emails which include significant details can also trigger reminiscence. For this reason, the software application passively downloads emails sent or opened from “*Microsoft office outlook*” and archives their details. The date and time of an e-mails arrival adds value to lifelogging data, but in addition the date and time of opening and reading the email would be more valuable and could make a great impact on memory when linked with other data captured at the time of reading the email. For this reason the prototype is tailored to extract detail from the email file type alongside screenshots of it when the file is open for reading.

5.3.2 Date visualization and interaction

Data and metadata generated by the lifelogging capture tools is uploaded so it is ready to be used by the lifelogging prototype. Simultaneously the data is organised, indexed and archived to achieve the main goal of the prototype; “*to easily access and retrieve user’ memory*” (see figure 5.5). In order to do this, I designed and built different software programs to deal with such circumstances and conditions during the data upload process. For instance, CatCam digital photos were lacking both a date and time stamp which means they might be useless. One of the softwares designed to resolve this issue allowed this information to be created passively for each single photo, apart from the first, whilst they are being uploaded. The software allowed users to manually insert the date and time the first photo was taken and then the software would automatically calculate and create the date and time of the rest of the photos by continually adding 10 seconds of time to the time stamp. Alternatively, the date and time of the first photo could be obtained from other data such as GPS location information.

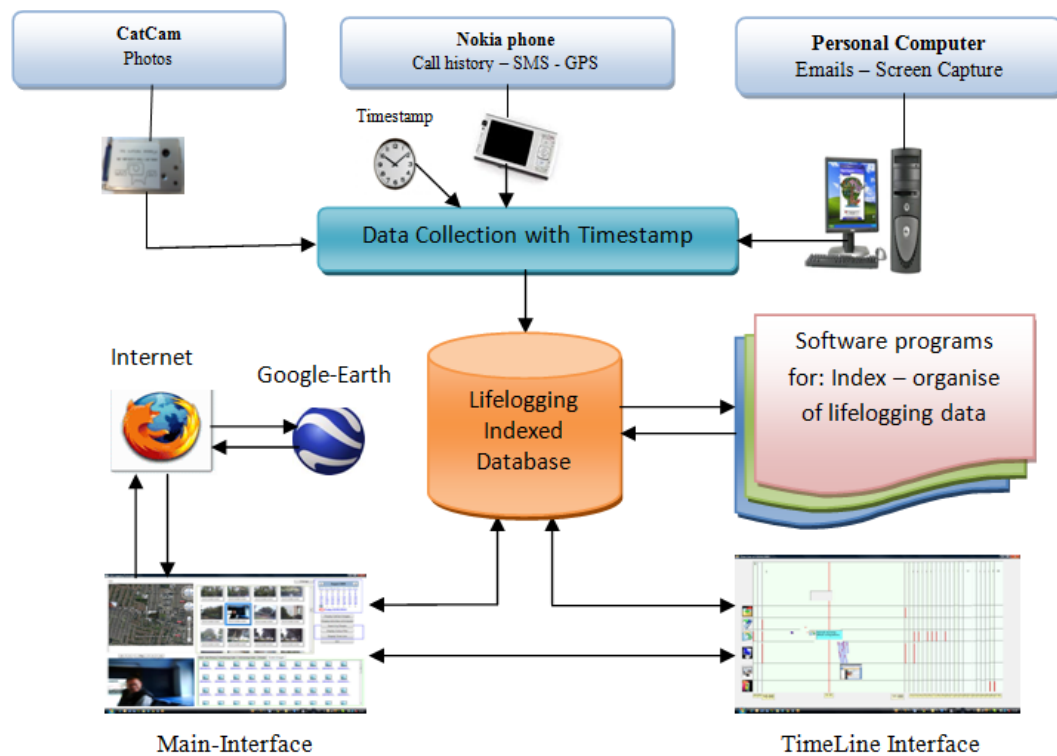


Figure 5.5 The first Lifelogging prototype.

The primary challenge in designing a user interface for multiple heterogeneous data is to turn raw data into more meaningful visual *events*. The user interface was designed to allow visual exploration, association and grouping of the data generated to allow users to search, browse and ultimately create *visual cues* (see figure 5.6). The data collection consists of a variety of different formats and I used the date and time to link and integrate data together to represent and tell stories about specific activities that happened at a particular time. Consequently, information about one activity could be used to cross-index to other activities. For example, suppose that we want to remember what we were doing when we received a phone call from someone two days ago. We can do that by locating that phone call, via the date and time, and then use this to access any other data captured at that particular date and time to deliver more detailed information about the event.

The user interface of the prototype could be divided into six main parts as shown in Figure 5.6. I called these panes. In the top right corner there is a calendar pane which is the central control of the prototype. It uses to select dates (year-month-day) of events that users would like to search, explore, or use the landmark date of that day to retrieve specific events. When users picked a specific date, CatCam photos can be explored in the thumbnails pane which is in the medial top of the prototype. Users can scroll

through each pane to explore all the photos collected on that day. In the bottom left corner we can see the map pane. Initially this pane displays Google earth's virtual image and the location of any selected item of data captured outdoors, such as photos, SMS, or phone calls, can be explored by clicking on it. The icon of the selected item appears on the journey path of the selected day.

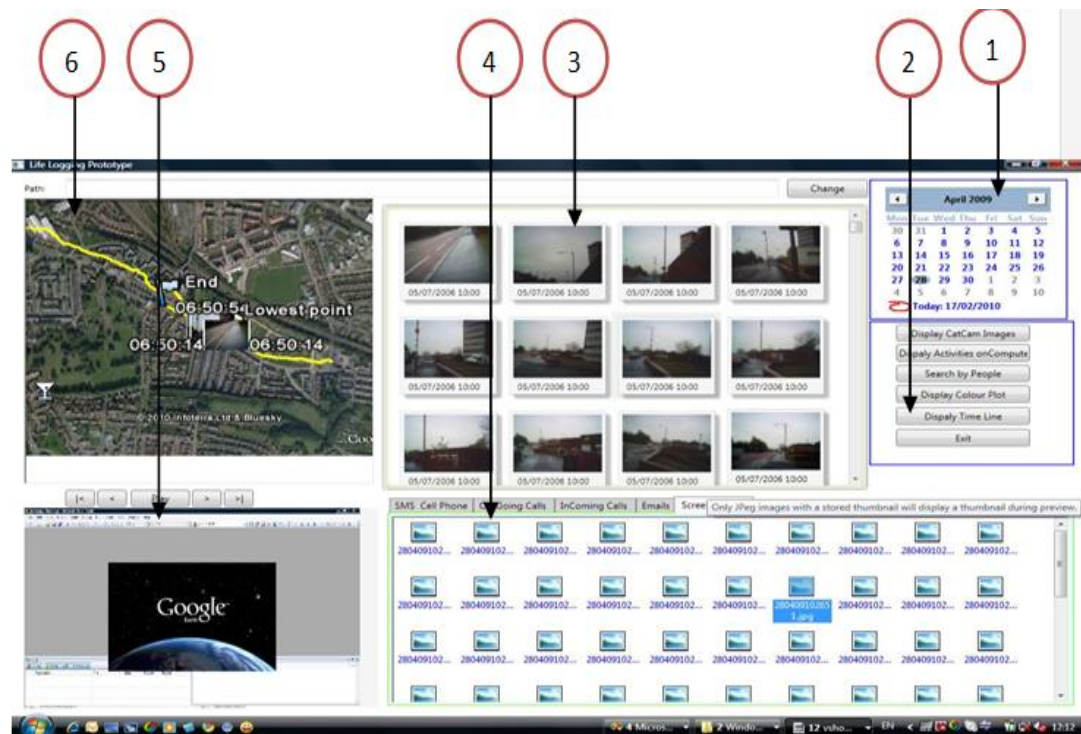


Figure 5.6 Lifelogging First Prototype

We can display a journey path as lines of random colour that appear on the Google earth to show the start and end points of any selected day trip, represented by the first and the last photos respectively. All CatCam photos, indoors and outdoors, are located on Google earth map to show users a high level overview of their whereabouts and to help users to remember their journey path and their movements. I distinguished between indoor and outdoor photos by the existence of GPS information. I argue that using such an overview method will provide more information to the users and support them to remember more details about their photos. All of the lifelogging data is grouped, associated and linked by date and time. This means that as the user interacts with one item the others that were captured on the same date and at a close time interval will be reacting. For instance, when the user selects a photo in thumbnails pane, the photo will appear again as a small thumbnail on journey path with a timestamp. In addition, phone calls and SMS which occurred 30 minutes before or after this time and date will be

highlighted as well. Furthermore, the photo zooming into “display pane” which appears in the bottom left corner. The display pane has five options to assist users in displaying their photos. The average numbers of photos appears in the thumbnails pane, which is approximately 3600 photos per day. To display and navigate through such vast amounts of photos manually would be a time consuming and tedious process. This problem was solved by producing a “Play” button to assist the users by displaying their photos as a movie. A playback method was used to display ten frames per second. This speed was judged by the participants and the researcher as being slow enough to allow changes in the scene to be viewed, but fast enough so that one day, which contained about 10 hours of capturing photos, could be displayed in about 6 minutes. I found that the other four buttons in the display pane were as useful to the users as the playback button. These were ‘locate first photo’, ‘locate last photo’, or ‘forward’ and ‘backward’ to display the previous or the next photo.

In the bottom right corner we can see the multi tasks pane. This pane is used to display and explore many types of data in one place and the complete information about a selected item, such as received and sent messages SMS, phone calls (incoming, outgoing, and missing calls), received and sent emails, or display images of computer activities.

5.3.2.1 Timeline

The previous window of the prototype concentrated on the location of each event to support lifelogging users to search, display and create cues for their memory. This window also has the same goal, but it focuses on time instead of location. The window is designed as a table which contains (24) columns and (6) rows as shown in Figure 5.7. Each column represents an hour, beginning at 08:00 am and ending at 07:00 am the next day. Each row represents only one activity. There are small red vertical lines to indicate there is some activities captured at that time, and to support the users in making a complete image of the whole day in just few seconds. This method was designed to enable the users to watch one day’s activities in few seconds. In addition, this was to support them in linking and remembering many activities that happened on that day, even actions that were not captured by any of the devices. I believe that presenting all lifelogging data at one time could assist a lifelogger to relive their past experiences.

The user interface is written in C sharp and Windows Presentation Foundation “WPF”. During the time of designing the user interface I continued capturing my personal data and use it to test, fix, and redesign the interface.

As illustrated in the first chapter, the thesis aims to explore how different types of data collection could support people to create effective and valuable cues to augment their memory. In response to the great amount of data collected through lifelogging, this method could support the elimination of redundant data or identify new data and metadata.

I believe that both sociability and enjoyment are cornerstones of the lifelogging experiments, participants should take pleasure in collecting their data and employ the user interface to search, browse, and respond to visual cues. There is little previous experimental research to examine what data could be collected for lifelogging technology or to measure how such data could stimulate and augment human memory to generate appropriate cues for the purpose of enhancing, and supporting human memory these are restricted to a small number of clinical studies (e.g. Hodges et al., 2006; Lee & Dey, 2008; Lee & Dey, 2007)

I believe that, the new experimental design must examine two phenomena participants' behaviour and their interactions. Participants must have natural or semi-natural behaviour whilst collecting their data and at the retrieval process. The experiment involved a natural group of participants to collect data from their natural everyday life environment.

5.4.1 Method

This study was conducted under two conditions that incorporated different ways of using lifelogging technology. In one condition participants used only their Organic Memory refers to the use of “non-augmented memory” to recall past life experience”. In the other, participants used the prototype interface to search, explore and create their visually appropriate cues to stimulate their memory to retrieve their past actions and events.

5.4.1.1 Participants

Three participants took part in the study, two of them male and one female. The mean age was 37.3 years. None of them had prior experience of using the CatCam or Nokia phone GPS, nor any related work with lifelogging. The two males are PhD students at Newcastle University, one of them is a computer science student and the other a chemical engineering student, and the female participant is the researcher's wife. She is a homemaker. She has been chosen as a participant for many reasons. Her data would be distinctly different from the others because almost all of her data would be captured and collected at home and that means it would include different actions and activities such as childcare, preparing food, watching TV, family and friends phone calls and activities on the computer (surfing the web, reading emails, Facebook, and others).

Whereas the students activities may involve more travel outdoors as well as lectures and studying. In addition, using her data would demonstrate more clue of many significant issues such as people behaviour during collecting their data, time they prefer to do that, and to be aware of any difficulty that may be appearing or they face while using the devices. Furthermore, privacy concerns are one reason for selecting her as a participant; being close and working together on her data would support me to better understand the significance of many things that she might mention and this could be very useful at the evaluation stage.

I believe that capturing activities at home could support people in creating valuable cues for their memory and to retrieve details such as how they spend their time at home, how they behave and even to monitor their diet plan. Thus, this is another context where I need to examine the effectiveness and the necessity of lifelogging. This could help me to introduce and argue that it is evident that new lifelogging technology is needed, for both indoors and outdoors as each one complements the other. Face-To-Face (FTF) observation interviews were conducted twice with all participants. Two of them took place at Culture Lab, Newcastle University, and the other interview was at a participant's home. The average time of the interviews was approximately 90 minutes. All interviews were recorded with the permission of the interviewees.

5.4.1.2 Procedure

This study was split into two stages. In the first stage participants were asked to use the proposed lifelogging capture tools to collect data from their everyday environment. The second stage focused on how to make that data available and meaningful for the users to display and search, and support them to generate interactive cues that enable them to stimulate their memory and assist them to retrieve more details of past events. At the former stage, I asked each participant to use lifelogging tools to collect data continuously for three weeks. I asked them to wear the "CatCam" camera to capture photos and turn on the GPS on the mobile phone to capture location information data for at least ten hours a day. In addition, I asked their permission to install two software programs on their personal computers, one of them to capture their computer screen and the other to download and archive their sent and opened emails passively. With regards to the privacy and security concerns, each participant's data and metadata were archived and saved on their personal computers and protected by a password. The second stage of the study focused on the designing and building of a new user interface to visually

present participant's data and that was able to support them in remembering details of their past experiences.

After approximately two months of collecting their data, participants were invited to attend two face-to-face observation interview sessions to test their ability of remembering some events from their logged days, first by relying on their organic memory and second by using the memory aid of the prototype user interface. In the former, participants were asked many open ended questions related to the actions and events of their logged data. I asked them to take their time and describe the details as much as they could to answer memory questions. The average time of these sessions was approximately 30 minutes. The latter session was divided again into two sessions, a training session and a direct observation session. In the former I introduced and explained, in detail, how to use each of the prototypes functions. In addition, I asked the participant to practice for a few minutes to make sure that they could become familiar with the interface. Next, I tested their familiarity and ability of using the prototype by asking them some training questions. My main goal for this task was to ensure that they could confidently access, locate and use all of their data as planned in the experiment. The average time of these sessions was approximately 20 minutes.

In the direct observation session, participants were ready to use the prototype interface confidently to search, display and create interactive visual cues. To make sure, I asked participants to use the prototype and answer a number of memory questions relating to a specific but typical event such as asking about lunch on particular days of . Examples of questions include Where did you go? What did you do? Who did you meet? With whom did you have lunch? What was the food? What were the topics of conversation? I asked them about news they received by email, SMSs or phone calls. All the questions I asked were open ended questions and participants were as long as they liked to answer the questions. These questions were typical of those used in prior studies of lifelogging (Sellen et al., 2007); (Kalnikaite et al., 2010). I asked the same questions for many different dates and times. The average time of these sessions was approximately 40 minutes. I believe that this method supported me in investigating participants' memory and allow me to track, monitor and investigate their ability to use the prototype interface to retrieve their past actions and events. In addition, facilitate the evaluation of their interactions and behaviour as well.

In both sessions I used four ways to record the session for later analysis. A log file was used to capture participants' activities and store them as text which was describing each action performed by the participants on the prototype interface. In addition, the SnagIt software was employed to record their computer screen. My motivation for this was to monitor, track, and follow the participants' navigation between their data to assess how they used the interface to create their cues. Furthermore, video was used to capture participants faces to monitor and understand their verbal and nonverbal actions and track their hands, body and legs movements. I consider that these movements would enrich the meaning of the data corpus and, therefore, my understanding. Moreover, I captured images of participants' computer screens every five second and used them as landmarks to follow the participants' navigation and to monitor activity.

After each interview the interview data was transcribed in details. For example, conversation including laughter or saying sounds for instance, “mmm” or “yeah” or any other nonverbal sounds such as gesture and face or leg movement were transcribed and analysis.

5.4.2 Data Analysis

The interviews were transcribed; recorded in written format as a “full script” and then I used grounded theory to code and process the full script. I followed two types of coding: Open coding and Axial coding as identified by Strauss and Corbin (Corbin & Strauss, 1990). I utilised the former to code or label words and phrases by identifying, naming, categorizing and describing event found in the full script. The transcripts were then organised into themes, categories and examples to allow reoccurring topics or themes to emerge. The latter type “Axial Coding” was adapted to categories via a combination of inductive and deductive reasoning. In this way I created themes by grouping codes or labels to words and phrases.

5.4.2.1 Using NVivo Software

To analyse the qualitative data accurately and confidently I used NVivo, a computer software program which has the ability to manage and analyse data. In addition, it has the capability to, code, organise and collate all of the interviewees' transcripts and relevant data. Each line, sentence or paragraphs in the transcript documents were reviewed and assigned one or more codes. Next, I looked for connections between codes through the use of several strategies after which these were interpreted. This could occur by using a variety of methods, most commonly is the sense of story which

includes attention to detail, descriptive vocabulary, direct quotes from those observed or interviewed, and thematic organisation. The aim is to measure individualized outcomes (how well the prototype meets individual needs) And look for the implementation process which focuses on learning and understanding how the prototype was actually implemented as well as where the prototype could be used. In the current experiment two steps were used to analysis the interview data. In the first step I used NVivo software to write the interviewees transcripts by exporting all interview video to NVivo and listening to each of them many times. Both the transcripts and video were examined many times to identify themes which were noted, given temporary titles and grouped with preliminary interpretations. This process was iterative and as the analysis progressed the themes were clarified, refined and added to. In the second part I used lifelogging evaluation software to monitor every single action that happened during the interviews to modify or clarify current themes or to add new themes.

5.4.2.2 Lifelogging Evaluation Software

Lifelogging evaluation is a very hard task and a grand challenge. Many researchers have done it in many different ways, almost all of them concerned with using Vicon Revue photos to augment human memory and what data could be combined to achieve best results.

In this PhD work I am concerned about how data and metadata can serve as cues to assist and encourage retrospective memory to relive past experiences. To do that, I need to track, monitor and understand every single action and behaviour, and understand the methods that participants followed and performed to generate their memory cues. I found that the best way is to design and build evaluation software that would present all the interviewees' activities and actions at once on a timeline graph (see Figure 5.7).

I believe that this method could assist researchers in following and understanding the participants' actions and behaviours more confidently when they replay and watch again all the participant activities at one time, together, at any selected moment. In addition, this capability could provide a high quality of information for researchers to understand and confirm the results of the interview data analysis. For instance, by clicking on a question not only can the answer be heard but all the participant's behaviours, actions, and movements that were tracked at that time can also be relayed simultaneously.

As shown in figure 5.8 the Lifelogging evaluation software involves seven panes. The right top corner (pane-1) shows the control pane containing five buttons to control the interface as a whole. Pane-2 is used to explore the interview video clips that were recorded by the video camera and all interview related data that is synchronised to this clip.

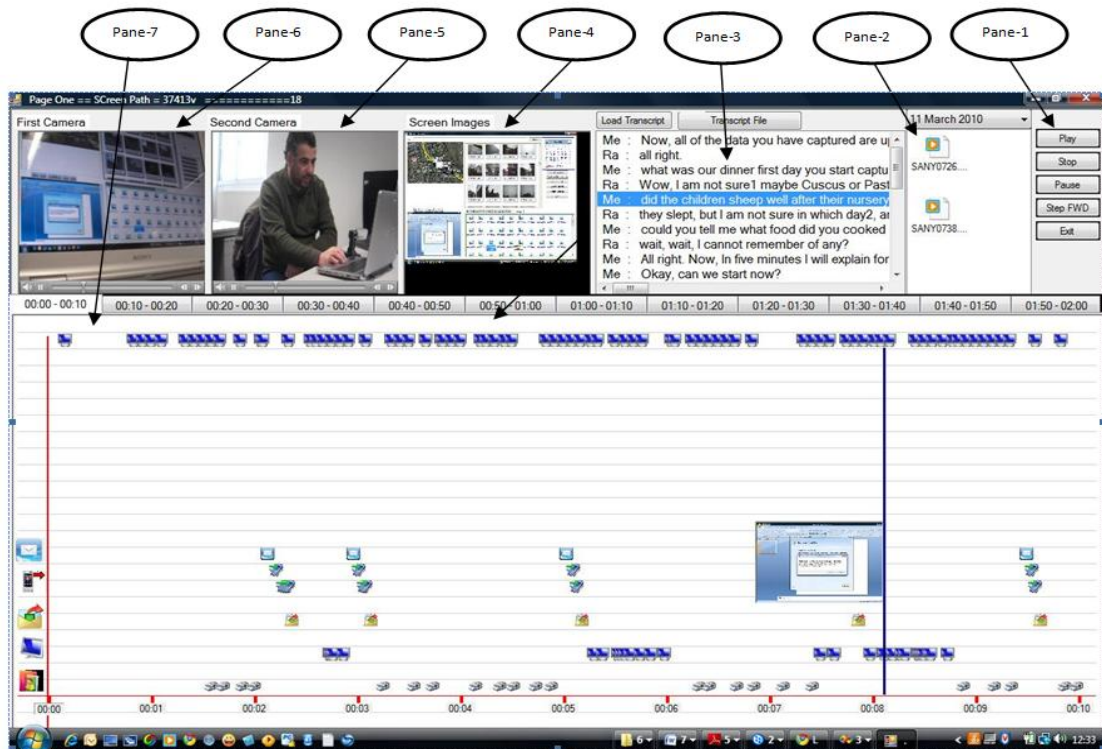


Figure 5.8 Lifelogging Evaluation Software.

captured from that time on. Computer screen images which are captured every five seconds during the interview would be located in pane-4. The advantages of using pane-4 are it can be used to confirm all of the other activities and to drag the control to any selected point. Pane-5 is used to display the interview video clips that were captured by an external digital camera. The main goal of this is to monitor and display the actions, behaviours and interactions of the participants with their computers. That means the video must display the whole participant's body especially their face, hands and legs to monitor every verbal and nonverbal action and movement. Pane-7 is used to display a video clip on a computer screen.

I used SnagIt to capture the participants' every single action and movement during the interview to track and monitor their behaviour. I believe that this technique would generate a vast amount of information and allow me to follow participants' navigations between their data and understand how they combine and access their data to create

valuable memory cues. Pane-7 contains every single piece of data that was selected during the interview, which were a maximum of two hours long. In addition, there is the time indicator to show the current time of the interview. This indicator could be dragged forwards or backwards to any point in time or to replay a specific part of the interview.

5.4.3 Results and discussion

The results will be presented in accordance with the aims of the study. Observations of the participants' behaviour during the interviews will be given first. I believe that people can rely on their organic memory (OM) to remember different pieces of information about their special events, such as a wedding, but they cannot remember details of specific events, for example conversations, people, emotions and feelings, food, or the weather. For example, people can remember every detail of the first night they slept in their new home, but are unable to remember anything from the last three or four nights. Furthermore, it is easy to remember someone visiting or a birthday party but it is more difficult to remember attendees' names and conversations without using a memory aid. In my study I found that participants cannot remember details of specific moments that happened repeatedly every day. For example, participant (A) mentioned that *"....they slept...but I am not sure which day... and I cannot remember for how long"* when I asked her whether the children slept after lunch on the first day of capturing her data or not. I know that this happened because the children often sleep after lunch time. In addition, participant (C) could not be certain about his answer when I asked him with whom he had lunch with on a particular day. He said *"... It's not clear in my mind ... I could remember exactly, but I think I had a lunch with my family that day..."* In addition, when he mentioned visiting a shop I asked him his reason for going there, but he could not provide any answer; *"... I went to the shop, but I could not remember why"*.

I found that participants occasionally could remember some of their everyday custom activities, but they could not give extended answers. For example, participant (B) said *"...it is too hard to remember details"* when I asked him to expand his answer about the good news that he had received by email during the date capturing period. I believe that remembering the date and time of a specific event without using a memory aid is very difficult. There are two possible reasons for this. First, individuals are very busy with their everyday lives and they deal with a huge amount of data. The second reason is the similarity of different activities occurring at the same place at different times could

confuse individuals and affect their memory or confuse a number of their actions and activities. For example, participant (B) mentioned a phone call but he was not certain about the date; “... *I had a phone call from my brother, but I am not sure whether it was first day or second day and what time.*” Participant (C) stated that they went to the University on specific day, but he could not remember who he met or talked with on that day; “... *I went to the University, I am sure I met many friends there, but I could not remember any particular one I had chatted with.*” Participant (A) was certain about sending an email but she could not remember the contents of the email itself; “... *I sent an email to my sister, but I could not remember wheatear I asked her about her children or not.*” Participant (B) mentioned that he worked at home at weekends but he could not remember when he started or stop; “... *I can remember I used my laptop at weekend ... but I could not remember for how long*”. Also he mentioned some news he saw on the internet but he could not remember on which web site; “...*I have seen this on the computer ... but I am not certain in which site...*”. Participant (A) attempted to recall one conversation she had with her family during lunch time on a specific day. She mentioned many different answers “...*we talked about my son birthday party... about the children school ... about the school trip ... No, No, I cannot remember exactly...*”.

Thus, I found that although participants attempted to recall events and to extend their answers, they could not remember and distinguish between their events, especially those which happened regularly such as daily routines. I observed that when I saw participants stop talking or close their eyes for a few seconds it seemed that they were attempting to mentally travel back in time to search for any clue that could support and encourage their memory to access the required information. Sometimes they did manage to recall the information and provide more than one answer for the questions, but none of them were certain. The reason for this uncertainty is the events such as “... *having a lunch with family...*” or “... *sleeping after lunch...*” or “... *using the personal computer...*” or “... *preparing food for the children*” or “... *calling closer friend...*” are not unique events; these happened almost every day and participants could not decide which one happened on a particular day and at a particular time. The same difficulties occurred with phone calls. They could not give an accurate answer even about the number of phone calls they received during a specific day whilst the data was being captured. External assistance could be someone who attends the same event (eye witness) or any other of the memory aids mentioned in the previous chapter. Another example is remembering food. I believe that people could remember what their lunch

was for the past two or three days maximum but no longer than that. I asked participants to go back three days in the timeline of their data collection and tell me about their lunch, such as who they had lunch with and what conversation they had, without using any memory assistance. I found that the participants found a very hard task and it was challenging for them to remember details or to confirm some information that they tried to recall. On the other hand, all of them became more excited and confident when I asked them to use lifelogging prototype as a tool to answer the questions.

I felt that when participants used the prototype interface and attempted to answer the questions they became more confident and certain about their answers. For example, when I observed their tone of voice and their way of talking change this encouraged me to ask them more questions and request them to extend their answers with more detail. I mainly asked them about things that did not appear explicitly in their data, such as what the weather was like, their emotional state, physical state, their intentions, thoughts, and even about the way food smelt and tasted. For example, Participant (B) mentioned remembering a place, actions and emotions when he searched his data and accessed some photos; “...*those photos captured at home ... that one shows my daughter’s faceshe was holding here new doll ... she was very happy...*”. In addition, he cited the caller’s name and mentioned some of the conversation when he located one phone call; “...*this phone call I received from my GP doctor... she told me about the blood test result ... I was very happy to hear that ...*”. Participant (A) talked about one incident of bad news when she opened one of her emails; “... *that email I received from my brother ... he says the swine flu has affected our city and local health care decide to close all of the affected schools ... I was very sad to know that...*”. Participant (B) described good news when he navigated and opened one of his SMS’s; “...*that SMS I received from my friend ... he told me about his graduation party... I felt very happy for him ...*”

I found that photos could allow participants to mention accurate information that happened before and also after the time of capturing the photos. For example, participant (C) mentioned many details when he searched his data and found one photo showing a baby’s face; “... *this is my daughter ... she is only one month old ... she has been just underweight when she was born ... my mother selected a name for her ... the children do not like her name ... they said it’s an old name*”. From the previous examples I can argue that logged data could support users to travel back mentally to describe events that did not happen at the time the data was captured but, more than that, it could support users to retrieve memories that happened before and after that

particular event. In addition, it could support the memory of related events that happened at that time or before or after the event by minutes, hours, or even weeks, months or years before capturing that data. These results increase my understanding of an individuals' memory capture and storage; that almost every single bit of information that has been seen, touched or listened to is recorded in the long term memory and they need only effective memory cues to trigger their memory to access that information.

Another example of this is although participants did not employ any device to record their voice or any conversation during collecting their data collection period they successfully managed to access and retrieve some of this when they searched and combined different types of data related to that event and captured before, after or during the conversation time. For example, when participant (A) talked about meeting with one of her friends, I asked her whether she could tell me about any of the conversations they had. She mentioned “...*those photos there captured when I meet one of my English language colleagues... I have not seen her for a long time... we had a short conversation ... she told me her husband found a new job in Durham city and they plan to move their after one week or so ... she asked me to visit her for tea and biscuit...*” In addition, participant (C) navigated to a specific time on a particular day and searched his photos. He mentioned different types of food he had and the taste of some of them, some foods he mentioned did not appear in any of his photos; “... *those photos show the lunch with my family ... that barbecue we prepared in the backyard ... it was very delicious and the smell was very nice ... although the pizza was little salty and spicy, but the children ate it...*”

I found that the photos could have an implicit impact upon participants' memory to remember not only their past events but to support them to remember some objectives they planned to do in the future and why they stopped for some reason or sometimes completely forgot to do it. For example, while participant (A) was exploring her data she remarked that she planned to do different tasks but because something else was happening at that time she changed her mind; “... *I was going to do some laundry ... I put the cloths near the wash machine, but the next photos there show me preparing some food for the children...*”

I believe that places are effective in triggering human memory to remember past events besides people and time. Participants remembered details of some events when they recognised the places they occurred in the photos taken on the virtual Google earth.

For example, participant (C) described his feelings at a specific time when he followed his path and recognised the place of his photos on the virtual Google earth. In addition, he mentioned some conversations that he had with people he met on his way; “... *those photos captured at the park ... I took the children there ... we spent nice weekend their ... the children enjoyed too much ... I had chat with that women ... her daughter joined the children and played with them ... the woman was very happy of that ... she told me her daughter likes to play with children ... she said she brings her daughter to the park every weekend*”. He navigated by using the virtual Google earth and mentioned different places; “... *the children like that lake very much ... that is the stream train path ... we ride it many times... the children yelled each time the train cross in front of them*”. Participant (B) followed his path on the virtual Google earth and he mentioned many places. He talked about the last location and his reason for being there “... *this is the royal station ... I went there to meet my friend how came from York to visit me ... I spent long waiting for him ... my friend said, his train delayed for mechanical reason and the train stops two times during their journey*”.

Participant (C) described many different places when she followed her path on the virtual Google. Some of the places do not appear on any of her photos and she navigated on the virtual Google earth to talk about different places close to her photos' path. She discovered one place when she found many photos appearing in a small area. She described the place and the reason of this; “...*those photos taken in the height street ... that photo show a lot of people standing in a semi circle in front of me ... they were watching magic game ... I saw one of my friends there, he was watching the show as well ... he told me he love to watch magic games and he stop whenever found any ...I left him there ... I can see may path there I went directly the University*”.

As illustrated above in the direct observation session, I asked questions about information, topics and memories that do not explicitly exist in the participants' data. my main goal for this was to encourage and motivate participants to create valuable cues from their existing data and to monitor their methods, strategies and behaviours when doing this. For example, when I asked them about things they have ate whilst they were capturing their data I found that they provided lots of information such as the places from where they bought the food and how the food tasted as well. In addition, I found that the food's smell might work effectively as a cue for participants to remember what food they have ate. Participant (B) mentioned place, food, time and memories of intentions when I asked him about food; “...*those photos show I am in the*

supermarket...that photo show my daughter ... I bought for her some chips and orange juice and apple juice for myself ... It was too hot and I felt parched and my daughter as well ... the path shows are going to the hospital ... we had an appointment for my daughter”. Participant (C) mentioned the place and the food he had ate as well when we asked him the same question; “... those photos show the Chine’s restaurant ... I bought some fish and chips from there ... I always buy my food from their ... they service spicy food”.

I found that computer screen images could significantly benefit the users, not only to support them to remember their past experience but to reflect upon themselves by watching their actions and activities on their computer. For instance, such images could tell them how they spent their time working or surfing the internet on the computer, reading papers, chatting with friends, or writing emails. In addition, for how long they use their computer and for how many hours per day. Furthermore, what time they often used their computers and why. For example, participant (C) described his location, actions and activities when he combined the photos and the screen images that were captured at that same time; “... those screen images there show I spent long time searching and reading papers ... I downloaded some of them ... the photos show my office ... I was in the University ... there is a gap in the screen images there ... I stopped working ... the photos show I was talking to my friend ... he was showing me some of his experimental results ... we went to the kitchen for coffee ... I checked my email when I back ... that image show the email I received from my brother ... he asked to send him invitation ... I did not do that for him ... I did not replay him ... that image show very related paper to my work”. Participant (A) talked about news she found on the internet when she explored the screen images of a particular day, but when she navigated forwards she recognised that the next few images did not belongs to her. She mentioned place, action and intentions when she combined those images with the photos; “... those images captured at sitting room when I was serving the internet and reading the news ... those photos belongs to the kids ... the images shows cartoon and the photos show the kitchen ... I was preparing some food ... all of these photos show the kitchen and what I was doing ... there, both the images and the photos show the computer screen ... I am back ... those images there shows I was writing an email to my sister, I attached her some of the kids photos ... that image show I was looking for coffee maker ... I bought one, but it is small and slow ...”

5.4.4 Discussion

I believe that human memory requires more external assistance nowadays, not only to create memory cues but to confirm information that has been retrieved as well. External assistance could be someone who attends the same event (eye witness) or any other of the memory aids mentioned in the previous chapter. Another example is about remembering food. I believe that people could remember their lunch for a maximum of three days previously but no more than that. I asked participants to go back three days in the timeline of their collected data and tell me about their lunch, such as who they had lunch with and what conversation they had, without using any memory assistance. I found that participants found this very difficult and it was difficult for them to remember details or to confirm some information that they tried to recall. On the other hand, all of them became more excited and confident when I asked them to use the lifelogging prototype as a tool to answer the memory questions.

I found that participants often tend to locate the photos of the event first and then they combine data that they captured during that period of time to talk and describe their events and past actions. In addition, participants often combine screen images, phone calls, or SMS to the photos each time they attempt to talk about any of them. In other words, I found that photos were the main basis for their search strategies.

5.4.5 Summary

In this study I illustrated that there are several types of data that people can collect and use for the purpose of triggering, augmenting and supporting their memory of past experiences. I found that photos were the most supportive and other valuable data could be integrated to increase the powerful supportive nature of the photos and to stimulate different types of memory for retrieving information. In addition, new methods of assessing lifelogging, the captured data and the prototype were introduced. All of this together increased my understanding of *how* lifelogging could assist people in remembering their past life experiences. I found that lifelogging through collected data works very well in augmenting and supporting people to remember past events and actions. In addition, I found that exploring lifelogging data in a timeline not only supports people to remember their past experiences but also enables them to tell stories about specific events when they see all of their captured data at the same time. On the other hand, the existence of some blurry and dark photos did not mean anything to the users nor could they add any new information to the activity itself. In addition, the

collected photos occasionally did not tell anything about the main activity itself as a result of pointing the camera in another direction or something covered the lens. Furthermore, capturing vast amounts of photos in a small closed place, such as the home or office, can confuse the users into recalling specific moments that at the time the photo was took do not make any sense. To avoid such problems I am going to look to capturing new metadata to enhance and support my collected data.

Chapter 6

IsstLog: A Movement Augmented User Interface for Browsing Heterogeneous Lifelogging Data

6.1 Introduction

With the first prototype, I found that capturing data and metadata is the easiest part of lifelogging technology and also it is the fundamental cornerstone of its process. In addition, I agreed and proved that raw data has a great ability to stimulate and trigger human memory, not only to recall past experiences but also to relive them. On the other hand, I observed that available data is sometimes powerless and users need extra information to confirm and to add more details about an incident or an event, and that sometimes they could not distinguish between, recognise, or remember numerous indoor actions and activities as a result of similarity between photos, or photos whose content was difficult to make out, such as ones that were dark or blurry. Furthermore, seeing the same photos of one place without extra information could be confusing to the people viewing them.

The first study, a face-to-face observation, allowed me to monitor, find, and understand the critical points of the prototype itself. For example, I tracked the steps that the participants followed to create their cues, the time they took to obtain that information and the number of movements that users made on the interface to achieve their goal. All of these observations motivated me to search and think about capturing extra interactive data that is able to provide more insight into experiences and is valuable to users when making associations between information and for stimulating their memory. I believe that logging past actions and events could support people not only in remembering their past life experience, but also in reliving events that are never captured by any other devices. Such data could also allow me to investigate novel ways to develop the previous prototype, to investigate the influence of using selected photos as landmarks for lifelogging users to directly locate moments that could help them remember episodes from their lifespan, and to examine the way such data and metadata reflects upon a lifelogger's past, present, and future life.

In this chapter, I discuss the process of redesigning and rebuilding the first prototype to establish an appropriate and suitable user interface that permits searching and interactive browsing and is capable of stimulating the memory and visually displaying past life experience in multimedia forms, and that would encourage users to respond and react to that data and utilise it as landmarks to gain further detailed information about their past life experience. During the redesign process, I also searched and looked more deeply for extra interactive data that people could use for activity recognition. To do this I focused on both lifelogging branches: passive capture and information retrieval process. For the former, I sought to be aware of what additional data and metadata to capture and how I should capture it. For the latter, I needed to think of how I could make that data and metadata visual, simple, and integrated to motivate users to create their visual cues and trigger their memory to relive their desired past experience.

I present IsstLog, a new approach to capturing and presenting large, diverse lifelogging data sets. IsstLog uses wireless accelerometers alongside other more typical lifelogging sensors to capture users' actions and activities. The user interface of IsstLog allows the log data to be searched based on the physical activity taking place. IsstLog is a system that gathers lifelogging data and presents a novel interface for its retrieval. The system captures data about everyday life from multiple heterogeneous sensors, including accelerometers worn on the arms and body and placed on various objects in the environment. It also captures and processes data generated by the electricity meter. The user interface allows for the display and searching of the lifelogging data and the creation of visual cues and bookmarks to support users' recollection of past events.

6.2 The IsstLog System

With regards to the all previous types of data and metadata captured and used in the first prototype, I found that more valuable data could be captured from everyday life experiences to make the collection more powerful, reliable, and meaningful. To do that, I extended the notion of the first prototype to focus more precisely on capturing and using activity recognition to monitor personal everyday actions and activities Figure 6.1. I included two electronic devices: accelerometers and electricity consumption sensing. I felt that such devices could generate new data that would be able to support users in monitoring and recognising activities that they could not identify in the first prototype. For example, accelerometers would be used to generate data that could be processed and used to show individual's movements such as standing, walking, or

running, as well as monitor and track the movements of selected indoor objects from the everyday environment, such as the front door, window curtains, fridge, toaster, washing machine, cooker, kettle, and microwave. Electricity consumption sensors were used to monitor electrical devices such as the television and lamps. I believe that such data could aid people and encourage them to access and retrieve their past life experience both indoors and outdoors, and also make an impact in the future of lifelogging technology.

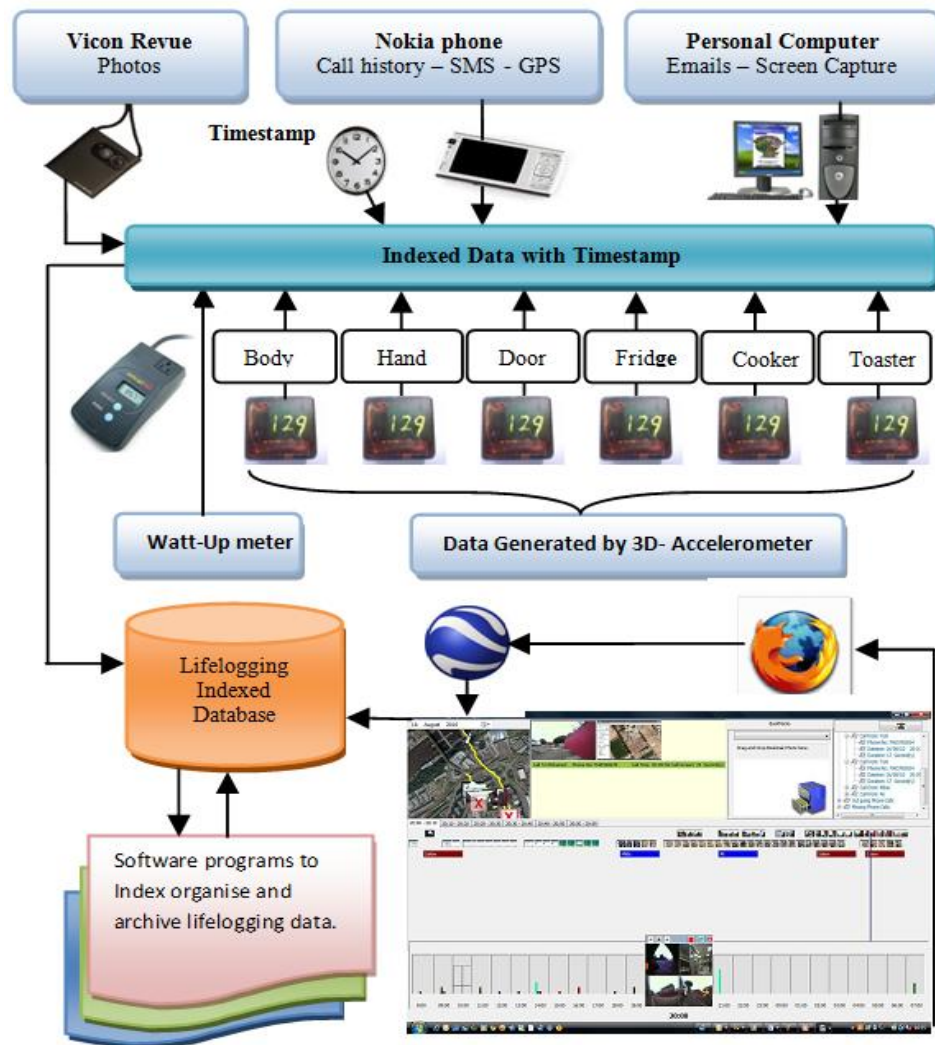


Figure 6.1 An overview of the IsstLog system

In this chapter I will introduce the IsstLog system to show what data we need to capture, the rationale behind this, and how to capture it. I will then illustrate how to visually present captured data.

The IsstLog system (named for its creator) addresses three major challenges in the field of lifelogging. The first of these is presenting an interface that can easily index and

search large volumes of heterogeneous sensor data. The second is allowing the identification of significant *events* in a daily routine, as opposed to the less significant individual *actions* that comprise that event, allowing users to mark or store these events in a way that simplifies and promotes reflection upon them during subsequent viewings.

The final challenge is in letting users use knowledge of their body movements throughout the day to identify key moments. To address those challenges, and inspired by [(Bush, 1945); (Bell & Gemmell, 2007); (Kalnikaite et al., 2010); (Sellen et al., 2007)], IsstLog collects multiple types of data that I expect that users would be able to use to construct event details in their mind by associating photos with the other available data captured at the same time.

The following design section is divided into IsstLog's two facets: the data captured along with the method of capture, and the data visualisation and interaction user interface it presents.

6.2.1 IsstLog Capture Tools

This section focuses on the keystone of the lifelogging: capturing and archiving data and metadata, and exploring the architecture of IsstLog. The main aim of this section is to assist the reader in making a clear picture of what data and metadata IsstLog intends to capture, what devices would be used to capture that data, and how users would use them to collect and archive IsstLog's data and metadata. IsstLog uses five different digital devices to collect data passively (see Figure 6.1). This section explains the rationale behind their selection and the implementation of the capturing process.

6.2.1.1 Motion data - Triaxial Accelerometer

In chapter two, "The Overview of Memory", I found that activities are a powerful way to augment human memory and reliably help people to relive their past lifespan. In addition, in chapter five I found that participants could not distinguish similar data captured at the same place at different times, and could not describe their action and activities at specific moments. These observations encouraged me to extend the notion of lifelogging to include accelerometer sensor devices to detect users' motion and the movement of their everyday environment objects. It also encouraged me to build and evaluate a new influential interface that is able to process and convert data generated by accelerometers into a tool for activity recognition. I argue that data generated by the

accelerometer sensor could be more valuable as lifelogging data in both indoor and outdoor activities. In addition, it could help users to segment their actions and activities into groups of events.

Nowadays, there are many smartphones with built-in accelerometers that can tell which way the phone is being held. I did not use smartphone accelerometers in this study for two main reasons. First, not all people keep their cell phones with them while they are at home or in the office, in such cases the accelerometer data will be useless. Second, data generated by a mobile phone located in the user's pocket sometimes does not represent the real activity. For instance, process data generated by the accelerometer in a phone placed in someone's pocket could tell us that the holder of that phone was sitting at a particular time, but could not tell us whether he was eating, working on the computer, chatting with someone, watching TV, waiting for an appointment and so on.



Figure 6.2 Triaxial Accelerometer

I believe that data generated by accelerometers has the potential to support users when they are locating the beginning and the end of particular events by showing when an action starts and stops. For that reason, I include multiple triaxial accelerometers that are worn on the arm and the body to detect the users' motion. Accelerometers are also placed on the following regularly used objects: the front door of the house, fridge, washing machine, toaster, cooker, coffee maker, and curtains to detect their movements.

I use a new triaxial accelerometer device to log the motion of environmental objects (see Figure 6.2). The device was designed and developed at Newcastle University in Culture Lab, under the supervision of Patrick Olivier. The device is lightweight and could be fitted to or embedded in many everyday objects. The battery and the storage capacity of the accelerometer could allow users to log data for more than ten continuous days. In this study I use two accelerometers to capture the users' movements, one worn as a watch on the user's wrist to log hand movements while they are eating, drinking, shaking hands and so on, and the other fitted to the user's body or kept in the user's

pocket. Many other accelerometers were fitted to or embedded in everyday objects to detect their movements when the users utilised those objects. I believe that the combination of the photos with the log movements of any of these objects would provide an opportunity for users to describe their events at that time.

6.2.1.2 Photographs - Vicon Revue

The **Vicon Revue** is a wearable lifelogging device that is worn on a lanyard around the neck, used to passively capture photos to create a personal visual recording of the wearer's life experience, which could be used to generate information that is able to augment human memory. It allows sensor- or temporal-based automated photo capture: photos are captured when there are changes in temperature, light intensity, or after a specified time interval. Sellen et al found that, compared to active capture, passively captured photos provided more support to people in the recall of past events (Sellen et al., 2007). Berry et al observed that Vicon Revue was a significant memory aid for patients suffering from memory impairments such as those symptomatic of Alzheimer's disease (Berry et al., 2007). For this reason, Vicon Revue is employed in this study to capture continuous still photos, instead of the CatCam camera that was used in the previous prototype.



Figure 6.3 Samples of Vicon Revue Photos

The Vicon Revue camera was chosen because it has several facilities that could be used to assist not only its user, but lifelogging researchers as well. For example, Vicon Revue has a long-life battery and a large memory that enables its user to capture their whole day without stopping to recharge the battery or change the card memory. It can capture an average of six photos per minute (≈ 360 photos per hour) for ten hours a day. In addition, it uses accelerometer sensors to delay the capturing time to avoid taking blurry photos. Furthermore, Vicon Revue photos are time stamped, which is not the case with the CatCam camera used in the first prototype.

This facility is very useful for presenting and linking together a photo collection with other lifelogging data by using both date and time as a key. For instance, to find out where they were when they captured a specific photo, a person can search and locate the date and the time of that photo in GPS data to retrieve the location information. The camera passively stores the value of each photo with a timestamp and the photo name in a separate file.

Vicon Revue also has a number of other sensors to trigger the camera to capture a photo passively. For example, it includes Magnetometer readings “MAG”, 3 axis accelerometer data “ACC”, temperature in degrees Celsius “TMP”, light level “CLR”, and passive infrared sensor “PIR”. I argue that those sensors’ values could be used to index or cluster captured photos into groups, as each of them presents a separate event. In this study I did not use any of them, but I used other sensors that I believed could index, segment, and group not only the photos but the whole data collection. Likewise, the size of the photos generated by Vicon Revue is approximately 20.0 KB, which means that ten hours of capturing photos needs only (≈ 72.00 MB). Figure 6.3 shows a sample of photos generated by the Vicon Revue camera.

6.2.1.3 Electrical power consumption – Electric meter

I argue that monitoring electrical consumption can track the use of electrical devices such as the TV, coffee maker, washing machine, or lamps, which could add more value to lifelogging when presented either separately or in connection with other data. In this study I logged TV power consumption data as an example to assess the impact of such data on users, specifically to see if and how they employed the data to identify and retrieve events. Similarly, generated data could allow users to monitor, understand, and remember how they spent their time at home and allow them to reflect upon their behaviour. In addition, using such technology with lifelogging projects might promote

organisation and reduce electricity consumption at home and work. For example, electricity consumption could allow users to track and monitor their appliances and could support them in the future to remember switching off any appliance that they do not use.

I believe that offering such data could be useful for both designers and users of lifelogging interfaces. For instance, a designer could use the generated data as an activity tool to group, index, and create events recorded by lifelogging technology. Likewise, the generated data could help users to recognise and associate that data with other available data collections to create simple memory cues that could be used to identify and distinguish activities that happened at a specific date and time. I argue that electricity consumption data could not only enable users to remember the time that they turned their devices on or off, but could help them to remember events such as with whom they spent their time, the conversations they had, news, or movies that they watched, as well as other details about the events such as their feelings or the weather while watching a particular program or movie.



Figure 6.4 Watts up Electrical Consumption Meter

I argue that such devices will allow users to monitor, understand, and remember how they spent their time at home and could reflect upon their behaviour. Such data could add more value to the other data and metadata that is collected at the same time to present the users' activities and to give them more support to trigger their memory. For example, a blurry photo or a series of photos showing the ceiling of a user's sitting room does not mean anything to the user, but when they know that their TV was working when the photos are captured then they could combine the photos with the consumption meter data to know that they were watching TV at that time. I believe that such data could help users to mentally travel back in time and try to relive that moment. Additionally, using such technology in a lifelogging project could open a new door for

researchers to not only look at how such data can assist people and reflect upon their future lifestyle, but to use that data as a tool to organise, control and reduce their electricity power consumption.

6.2.2 IsstLog devices and generated data and metadata

All the devices used in IsstLog offer a different data with timestamps as metadata (see table 6.1). These devices allow us to easily associate and link any data generated from one device with data generated from another, as well as facilitating and composing IsstLog to work interactively. Furthermore, this would add more value, meaning, and power for the IsstLog system. The following table shows IsstLog devices and their generated data and metadata (see table 6.1).

No	Device	Capture	Metadata
1-	Vicon Revue	Photos	Date and time, GPS data, sensor data such as (temperature, light density, accelerometer data).
2-	Nokia cell Phone	Call history: incoming-calls, outgoing calls, and missing calls	Date, time, and GPS - location information data.
		Received and sent short messages	Date, time, and GPS - location information data.
3-	PC computer	Regularly download emails and capture PC screen every five seconds.	Date and time.
4-	Watt-Up Electricity Consumption meter	Electricity Consumption of one selective device such as TV.	Date and time and voltage used by that device.
5-	3D- Accelerometer	Movement of human body and movement of their environment everyday objects.	Process accelerometer output to produce interpreted activity data.

Table 6.1 Lifelogging devices and different types of output

6.3 IsstLog UI: Data visualization and interaction

The primary challenge in designing a user interface for lifelogging data gathered by multiple heterogeneous sensors is allowing users to turn raw data about *activities* into more meaningful *events*. The UI to IsstLog was designed to allow visual exploration, association, and grouping of the data generated so that users could search, browse, and ultimately create *visual cues* and *bookmarks*. This means logged data must be uploaded, organised, and indexed to be usable (see figure 6.5).

I believe that lifelogging interfaces should be more productive, approachable, simple, and fun, while being able to accomplish their users' goal and allowing them to utilise their data interactively. That means when the user highlights any of their available data, all of the data connected to it should also be highlighted. For example, clicking on Vicon Revue photos would activate the virtual Google Earth to explore the location of that photo on the map. In addition, all accelerometer graphs would show movements of the objects to which the accelerometer was connected and the movements of their body and hand at that time.

I used Google Earth instead of simply Google maps because I found that the C Sharp programming language include powerful classes and functions to control Google Earth more easily than Google maps.

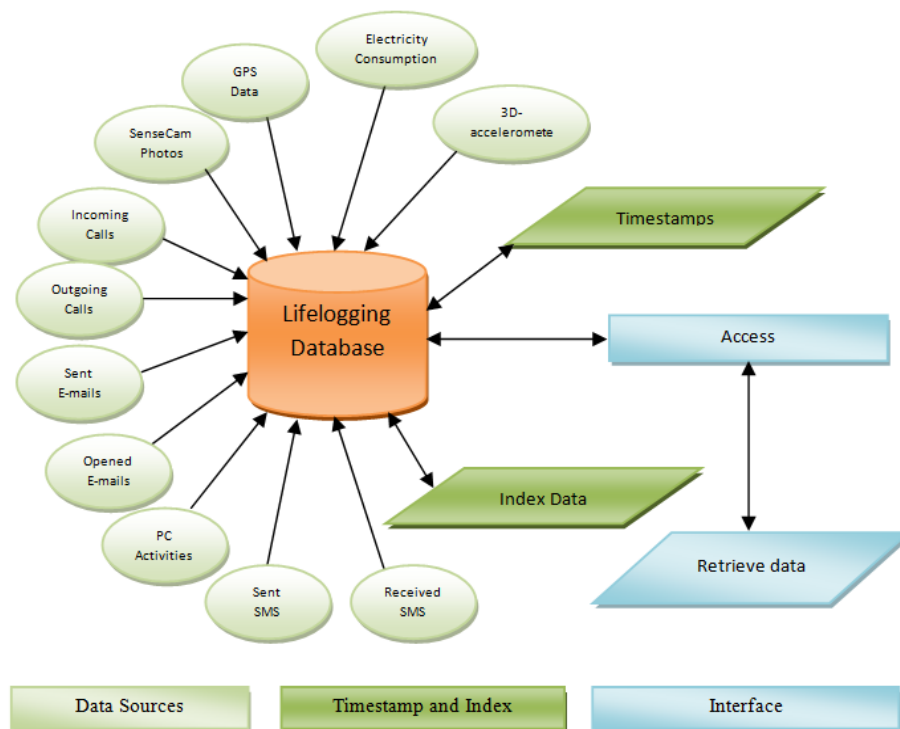


Figure 6.5 lifelogging connections of data and metadata.

With the first prototype I concluded that a photo's location sometimes works better than the photo content itself in terms of helping the lifelogger to travel back in time and remember not only their events but their emotional state as well. I argue that location information would be very useful for people to recall past events, especially when they cannot remember or recognise some of their photos' contents. For instance, knowing the time of one photo and its location on Google Earth may be sufficient to recall past events and actions that happened at that time and in that particular place. This is the

main reason that I was encouraged to build a user interface that was able to combine both the virtual Google Earth with a timeline on one screen. I believe that this facility could help users to know the order of their events by presenting the time of occurrence and the location information for each date that is captured outdoors. The next section explains this in further detail.

6.3.1 Designing the IsstLog Interface

I believe that lifelogging interfaces should be productive, approachable, simple, and fun, at the same time as accomplishing their users' goal and allowing them to annotate their own data for later reflection. Figure 6.6 illustrates the IsstLog interface. A photo's location may sometimes work better than its contents to help the lifelogger to mentally travel back in time to remember not only events, but their physical and emotional states as well. For example, seeing the time of one photo and its location could be sufficient to enable recollection of events and actions that happened at that time and in that particular

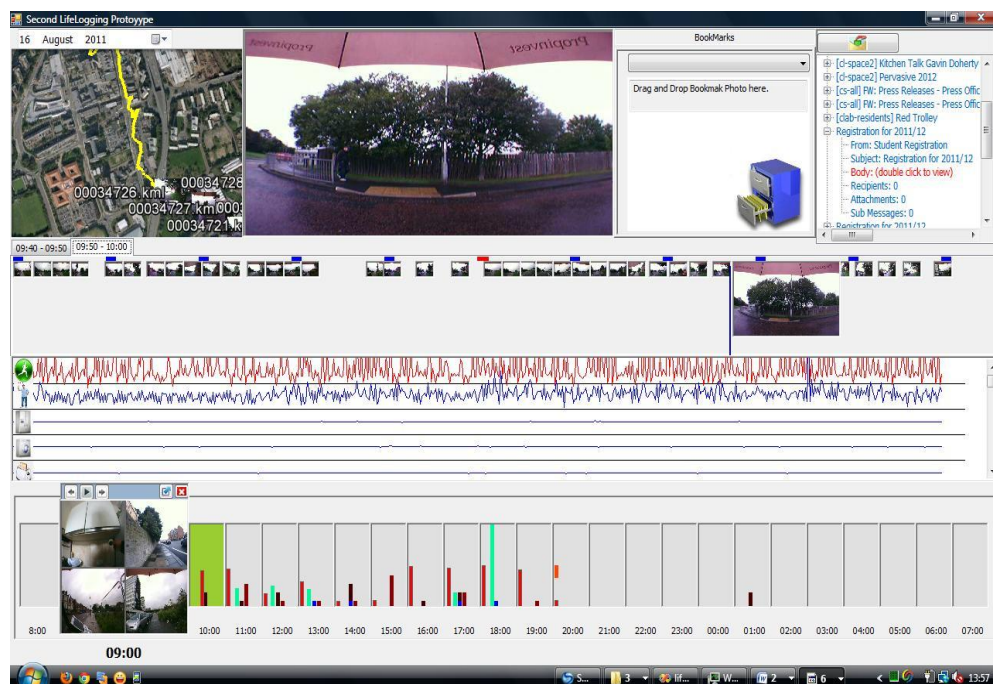


Figure 6.6 IsstLog timeline view, candidate photos are displayed in the bottom right, an hour's activity can be seen in the adjacent columns, the green column represents an hour in which the activity took place outdoors, the movement data is seen in the graph plot, the Google earth view is in the top left crner, the video of the hours photos is playing centre top and bookmarked items are navigate in the two top right boxes

place. For this reason, IsstLog combines Vicon Revue photos, phone calls, text

messages and best guesses about whether the user was indoors or outdoors at the time of capture with the location of the data on Google Earth. User's positions are captured

every second and IsstLog compares and pairs photo, phone call, or SMS timestamps with GPS timestamps ± 5 second. IsstLog offers a calendar to select and access data from a specific day and allow users to navigate between their data. (See figure 6.6) Days on which activities took place are highlighted to save users' time and to avoid them selecting and opening dates that do not contain any activities. Selecting a specific date gives a graphical view of all the activities within 24 hours, starting from 8:00am and ending at 7:00am as shown in figure 6.6. In the first study I found that most people's activities started at 8:00am, and this time was discussed with the participants in the evaluation of the first prototype.

Each activity is presented graphically as vertical lines on the hours pane with a different colour. I chose to do this for two main reasons. The first is to provide a complete summary of a specific day. I expect that users could identify the type, quantity, time, and place of any activities just by looking at their activities graphic lines. The second reason is to save users time and keep them from opening hours that do not contain any activities. Indoor and outdoor hours are distinguished by using different background colours to allow users to identify where they spent most of their time.

Selecting specific hours allows users to monitor the movements of their hand, body, and their objects, and also to monitor four photos, each representing a quarter of the hour, that I call *candidate photos*. When an hour is selected these four photos appear. Control keys also appear on the top of the photos to allow users to navigate to the first or last photos of the hour, move forward or back step by step, play back the photos of that hour as a video, or explore that hour's data on a timeline view. The control keys allow users to display the selected hours' photos as a movie at a speed of five frames each second, which means that 350 Vicon Revue photos would be presented in one minute and ten seconds, the number of frames and the video speed discussed and argued in the first prototype. Control keys provide other functions such as "pause", "continue", and "stop", to allow users to access their photos. Furthermore, they allow them to navigate forward or backward to provide them with more of an opportunity to think about and associate their data, especially during the searching process. Such facilities would assist easily users with searching and display their collection easily.

The timeline is split into six pages, each representing ten minutes, to display photos, screen images, SMS messages, phone calls, emails, movements of the hand, body, and objects, and the electrical consumption graph. The timeline page shows a timeliness

indicator moving from left to the right that zooms in on any data when the indicator reaches its time. All the photos taken play like a video. In addition, Google Earth also moves to show the places where that data was captured. Users can drag the time indicator forwards or backwards to locate any of their data on the timeline (see appendix B for more details). They can drag and drop any photo they find valuable to save it in the bookmarks. Finally, they can create visual cues; these are made from single pieces or combinations of data and appear enlarged in the timeline view to highlight specific events at a glance.

6.4 Bookmarks

The bookmarks are designed for two main tasks. The first is to allow users to archive valuable photos, or *memorial photos*, each time they revisit their original data. The second is to enable users to explore those photos in different ways. For example, they can have them display one by one or explore specific photos with the original five minutes of data captured before and after the photo on the timeline. This capability is intended to save users from searching a vast amount of data each time they revisit it or when they only wish to relive interesting moments. Furthermore, displaying ten minutes of contextual data on the timeline could support recall of the original reason for selecting that photo as a bookmark.

The IsstLog interface allows users to check and associate their phone calls, SMS messages, and emails directly by selecting a specific date. In addition, selecting any of them would allow users to explore the original data in the same way as a bookmarked memorial photo. Thus, bookmarks could be defined as a simple tool to summarise, shrink, and archive lifeloggers' past events and actions for later use. I believe that this could save users time and let them avoid searching a vast amount of data, as instead of searching day by day and hour by hour, IsstLog users could use bookmarks to find their interesting memories filtered, sorted, and archived. This is especially useful considering that the average number of captured photos would be 3500 per day or approximately 1,277,500 per year. I argue that searching such a vast amount of data would be a very hard and time-consuming task. For that reason I used the bookmarks in IsstLog as a tool to allow users to archive their interesting and valuable memories in one place and to use their memorial photos as anchors to associate and link only valuable data. I argue that displaying one memorial photo in ten minutes on a timeline could support users in making a complete picture of that action and event, and allow them to remember the

reason behind selecting that particular photo. In addition, bookmarks could reduce the cognitive and the physical load of recalling past events by aiding the memory, keeping track of memorial moments, facilitating the process of reliving events and speeding information access. They also allow users to easily find and recall specific events or actions. I designed the bookmarks function to do two different tasks: to allow users to save bookmarked photos for later use, and to enable them to explore that bookmark in different ways. For instance, bookmarked photos of one day could be explored one by one, or displayed as a movie of five frames per second. In addition, “play”, “stop”, “continue”, “fast-forward” or “rewind” functions allow users to navigate their bookmarks. Furthermore, users can use a bookmark to display all of the original data captured at the same time as the selected bookmark in ten minute intervals.

6.5 Summary

This chapter described the main parts of the IsstLog system for capturing and visually presenting vast amounts of heterogeneous data. The first part explored what data I intended the system to capture, why, and how. Furthermore, it described the appeal and the main features of IsstLog electronic devices. The second part described in detail the architecture of IsstLog, explaining the main features of the system.

Chapter 7

Evaluation of IsstLog

7.1 Introduction

Two studies were conducted to assess the IsstLog prototype. The first evaluation highlights certain ethical considerations. The second documents new strategies that were developed in response to the availability of activity data and also shows how the personal movement data can support users moving from identification of actions to the identification of events. In addition, it identifies new strategies and methods that people could follow to create their visual cues.

IsstLog attempts to promote three activities: Searching and browsing lifelogging data, visually combining multiple heterogeneous types of data to create visual cues, and the access and retrieval of their past life experiences. To evaluate the success of the design two studies were ran. In this chapter I first discuss, in general terms, an attempt to evaluate the system which was problematic and highlighted some ethical considerations for this sort of system. I document a second study of this system which shows that visualizing the movements of the users' hand and body facilitates the grouping of activities into events when combined with the other data captured at that same time. In addition, the ability to search for specific movements significantly reduced the amount of time that it took to retrieve data related to specific events and allows users to resolve otherwise ambiguous moments in the IsstLog data where other sensors could not gather optimal data. The study reveals three major strategies that users followed to understand the combined data: skimming sequences, cross sensor jumping and continued scanning.

7.2 Initial study

In the first study two males and two females who already knew each other socially were recruited to take part in a one week study in a similar format to the one documented after this section. The mean age was 34.7 years. None had prior experience of using the Vicon Revue or smart phone GPS, nor any related lifelogging technology. Two females and one male were MSc students at Northumbria University. The two

females were business school students and the male was mechanical engineer. The second male was a PhD student at Newcastle University electrical engineering.

Participants had one initial interview at the start of the data recording period where they were given the lifelogging tools. They then had a subsequent interview after a week's data collection to reflect on the data.

The study was completed after one week and interviews were conducted with the participants in which they reflected in detail about the data that was gathered. When the researchers started to analyse the lifelogging data, however, inconsistencies started to appear. Initially, technical issues were suspected and at this time the second study was started to gather more complete, usable data. Further investigation of the data collected in the first study, however, revealed that the data which the lifelogging tools had been collecting had been tampered with. Screen shots showed emails that were deleted from the collection and SMSs' appeared in the log of sent and received messages but the contents of the SMSs themselves were not stored. It emerged that more than one participant had discovered how the system stored some parts of its data and had been tampering with the data that was being logged on their computers to hide certain, extremely personal activities. This had happened despite the participants being aware of how to disable the capture technology (they had been told how to do this in case, for example, they wanted to use the bathroom) and knowing that they could request any or all of the data be destroyed without being viewed.

In addition, it became clear that some of the participants had simply felt uncomfortable about being filmed discussing even mundane activities. This behaviour was noted by the researcher conducting interviews who, while chatting with the participants, had questions freely answered that would later be avoided during filming. The participants had all signed the consent form that clearly explained they would be filmed and at that time had expressed no problem with this. In light of the failure of this study, the second study was conducted with a smaller family group who were much more comfortable with being involved in the process.

7.3 Longitudinal study

In order to better understand how users engage with the data a case study was ran with a couple (32 and 37 years old) living together with their young children (5 and 7 years old, the study does not include the children themselves as participants, but some of their

activities and actions captured by their parents capture devices. The participants were close friends of the researcher and their mother language was not English. In all the interview sessions they used “Arabic” to think aloud and talk about their events. I selected close friends because I believe that they would be diligent in their data collection and have less concerns regarding privacy.

The capture and retrieval stages were overlapping. Participants used capture tools on the same dates to collect their data for three weeks (see figure 7.1) with each participant attending six sessions of the direct observation interview. In each of these sessions they used the IsstLog interface for an average of 90 minutes to talk about events, actions and activities that happened in the indicated weeks. They used the IsstLog interface and performed a think-aloud exercise to describe the events and activities that happened in the preceding week.

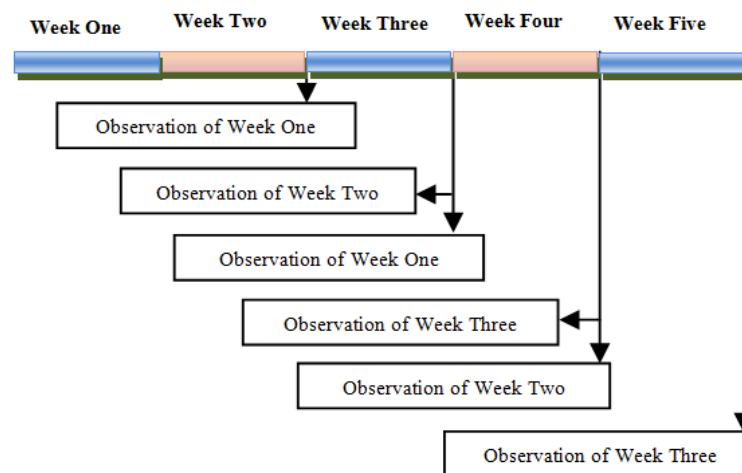


Figure 7.1 Direct observation schedule

A

larger study was attempted prior to this but the participants, who were all friends, became uncomfortable with the intrusive aspect of the technology and withdrew (this issue is revisited in the discussion). Six direct observation sessions were applied in the participants’ house. The average time of the sessions was approximately 90 minutes. All sessions were recorded with the permission of the interviewees.

Participants were asked open ended questions and participants were given as long as they liked to answer the questions as with prior studies of lifelogging (Sellen et al., 2007); (Kalnikaite et al., 2010). They were encouraged to describe, in detail, their

memories. While they used the interface to answer these questions, they were asked to explain the strategies that they used to search or browse the data and create their visual cues. I asked them about different actions and activities they did on particular days by asking what, when, where, who, why and how these occurred. Participants used the prototype twice each week to answer and describe their events. This allowed observation of how their strategy altered when revisiting previously viewed data.

I used four methods in parallel to record the sessions for later analysis: (1) log files captured participants' movements and actions while they used the prototype to record each click as a text description in a text file; (2) SnagIt software recorded the computer's screen as a video; (3) a camera captured participants face and body language to contextualize their utterances and; (4) the computer screen was captured as screen images and used as a landmark to follow and track participants navigations. At the end of each direct observation session the conversations were transcribed verbatim and coded looking for strategic details and reflections on actions, intentions, places, physical state, emotional state, time, thoughts and conversations.

7.4 Results

The analysis of the direct observation sessions revealed that users had three main strategies to locate data: skimming, multi-sensor-jumping and continued scanning. These three categories are derived from the graphical representations of selected examples in the transcript (see (see appendices E11, E12, E21, E22, E31, E32, E31, E32, R11, R12, R21, R22, R31)) and comparing these to each other. These three categories were derived by drawing graphical representations of selected examples in the transcript and comparing these to each other. In the graph participants' actions and activities are presented visually to simplify the strategies that participants follow to create their visual cues, what data they combined, and what memory resulted. For example, figure 7.2 shows how participants (E) combined his photos with the logged data of the accelerometers movements and what memory he retrieved.

7.4.1 Skimming

Users employed superficial viewing of the aggregated data, which I term skimming, primarily in their first viewing of data while looking for events they remembered had occurred and which they wished to discuss. The skimming tended to focus on three specific sets or combinations of sensor data as described below.

7.4.1.1 Skimming candidate photos then hand and body data

Users often used this strategy to search and locate specific events that happened at a particular time, and then they explored that hour's data on the timeline when they found indications that that hour could include their target goal. For example, figure 7.2 illustrates a strategy that participant (E) followed to create his visual cues. Participant (E) described how he combined the four candidate photos with the movements of his hand and body [EW31-192] “... *I visited Vodafone shop*”. At the same line he mentioned he had memory of his intention; [EW31-192] “...*I have been there to buy top up voucher*”, and the data about his body and hands movements encouraged him to mention thoughts [EW31-193] “... *I found Jamal there ...he was looking for a phone offer*”(see figure 7.2)

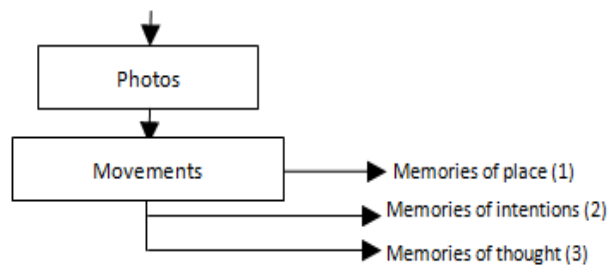


Figure 7.2 Participant (E) Skimmed the candidate photos then his hand and body movements.

Participant (R) mentioned memories of places when she combined the four candidate photos with her hand and body movements - [RW12-16] “...*the four photos were taken at home*”. She described the environment [RW12-17] “... *as I can see there the children appear in the third and fourth ones*” and her memories of her thoughts [RW12-18] “...*the school does not start yet*” that she identified looking at the photo (see figure 7.3).

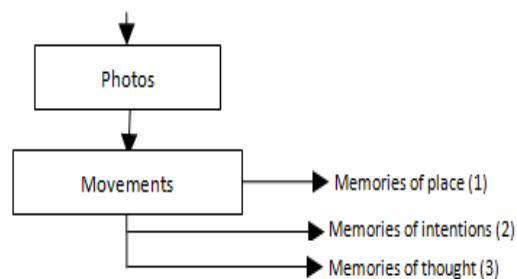


Figure 7.3 Participant (R) Skimmed the candidate photos then her hand and body movements.

Participant (E) describes different places and events when he combined the four candidate photos with the log of his hand and body movements; [EW32-25] “... *the photos captured in London ... that is Victoria station*”, as well as time; [EW32-26] “... *the bus arrived exactly on time*”.

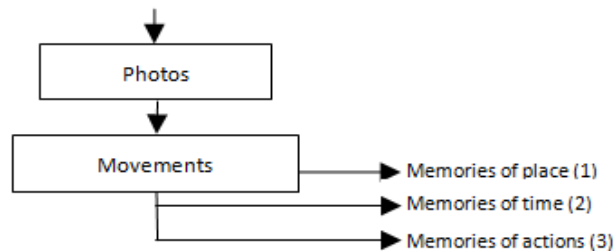


Figure 7.4 Participant (E) Skimmed the candidate photos then his hand and body movements.

He mentioned that the combination of the photos and his body and hand movements encouraged him to mention action; [EW32-27] “... *there we were walking out of the station ... that photo shows Khalid in front of me*” (see figure 7.4).

I found that using the combination of the four candidate photos with hand and body movements could support users to create a general idea of where and how they spent their time at particular hours and help them to navigate forward or backward to pick up the appropriate time that included their target goal. For example, Participant (E) navigated to a specific hour and combined the four candidate photos with his body and hand movements and then he navigated to the next hour as he mentioned his target goal could be in the next hour. He navigated to the next hour and did the same procedure and then he explored that hour’s data on the timeline.

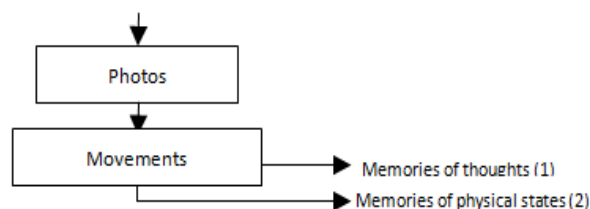


Figure 7.5 Participant (E) skimmed the candidate photos then his hand and body movements.

He cited some indications that related to his target goal. He mentioned thoughts [EW32-73] “... *it was a dark and cold when we get off the bus*” and described his physical state

at that time [EW32-73] “... *I had difficulty of moving my legs for few minutes*” (see figure 7.5).

In addition, the interface could allow participants to describe in brief some actions and events that happened at a specific time. For example, participant (E) described in brief some actions and events that happened at a particular time when he combined the four candidate photos with the log of his hand and body movements.

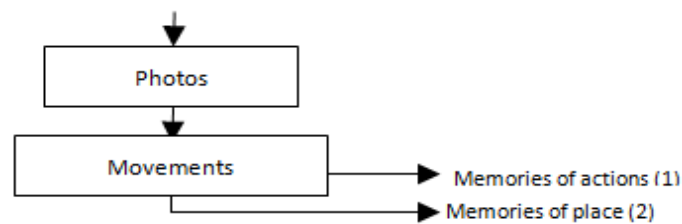


Figure 7.6 Participant (E) skimmed the candidate photos then his hand and body movements.

He pointed to the first and second photos and mentioned actions, [EW31-234] “...*I was working on the computer*”, and then he pointed to the third one and cited place [EW31-235] “... *I am in the high street*” (see figure 7.6).

Participant (E) described his places and intentions when he combined the photos with his hand and body movements; [EW11-43] “... *I am in the shop at the shoes section ... I was looking for new shoes for my son*”. The available data encouraged him to explore his data on the timeline and search for a particular action; [EW11-44] “... *that is the one I bought*”. In addition the interface supported him to travel mentally back in time and talk about conversations and emotional states that were caused by that event [EW11-45] “...*my son did not like it, he said*” (see figure 7.7).

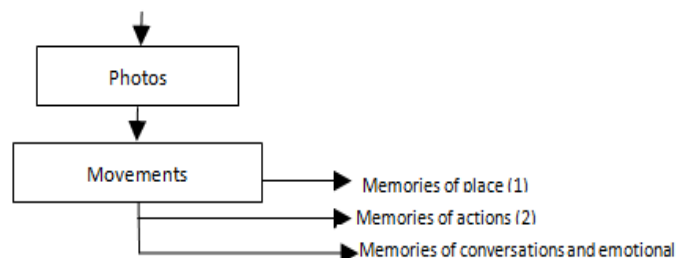


Figure 7.7 Participant (E) skimmed the candidate photos then his hand and body movements.

Participant (R) mentioned where she spent an hour when she found the four candidate photos were taken from one place; [RW12-16] “... *the four photos were taken at*

home”. She described the environment; [RW12-17] “... *the children appear in the third and fourth photos*”. The available data also encouraged her to add thoughts [RW12-18]; “... *the school does not start yet*” (see figure 7.8).

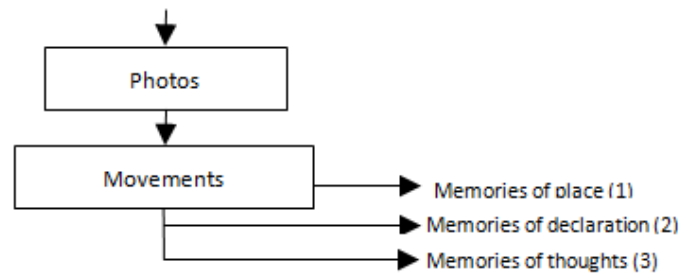


Figure 7.8 Participant (R) skimmed the candidate photos then her hand and body movements.

I found that users often relied on time to navigate between their past actions and events. In addition, they used the four candidate photos to locate the beginning and the end of each event. Furthermore, users combined the four candidate photos of each hour with their body and hand movements to monitor their actions and events at that time and to describe what they were doing. Moreover, the combination of four candidate photos with the log movements’ data by hand, body and objects could allow users to provide more details every time they revisit their data again.

7.4.1.2 Combining candidate photos with objects and movements

Users would look at their objects’ movements to navigate the timeline and access their actions and activities at home by examining the four candidate photos. For example, participant (R) combined the movements of the objects with the four candidate photos to search for times, actions and activities she performed in the kitchen. She described some actions; “... *there I can see a long movement of my hand also I can see a movement of the fridge and the cooker as well... I was preparing some cakes*”.



Figure 7.9 Participant (R) Combined the candidate photos with the objects movements.

This interaction highlights the participant’s ability to interpret their recorded actions rapidly because of the availability of contextual movement data. When examining the

photos of the event, participant (R) expanded on her actions; [RW12-104] “... *I cooked many things at the same time*”..

In addition, the available photos encouraged her to recount her thoughts at the time; [RW12-106] “... *Yes, one of the cakes was little bit salty...it was the first time I cook that kind of cake...I learned it from TV show*”. She joined the TV graph to the data and said; [RW11-32] “... *I left the TV working when I was in the kitchen ... and nobody was watching it*” (see figure 7.9)

Participant (R) mentioned the time and visitor’s name when she combined the four candidate photos with the front door movements; [RW31-148] “...*that movements shows when my friend came to visit me*”.

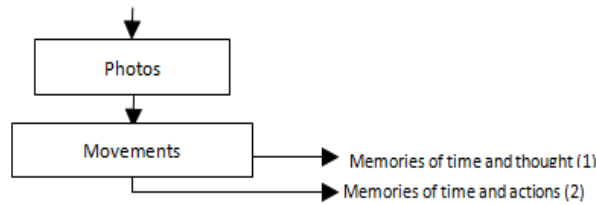


Figure 7.10 Participant (R) Combined the candidate photos with the objects movements.

She also cited actions and time; [RW31-149] “... *that one there shows when we went out ... this is the door movement when we went out ... those photos there shows we are in main street*” (see figure 7.10).

Participant (E) mentioned his arriving home and at what time when he combined the log of the front door movements with the photos; [EW21-77] “... *that is the front door movement when I arrived home*”. He cited actions when he combined the log of front door movements with the four candidate photos and with the log of his body and hand movements; [EW21-79] “... *my daughter was waiting for me*”, and the data about his body and hand movements encouraged him to mention some conversations; [EW21-79] “... *she told me she did not go to the school*”. He also mention emotional states; [EW21-80] “... *she was very nervous*” (see figure 7.11).

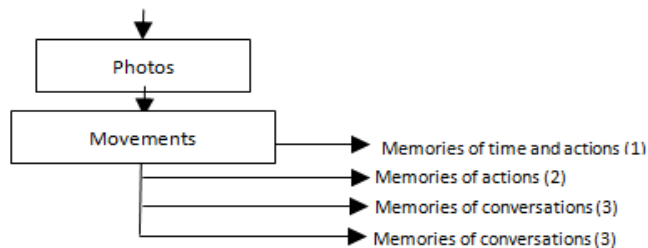


Figure 7.11 Participant (E) Combined the candidate photos with the objects movements.

Participant (R) combined the object's movements with the photos and with the electricity consumption of the TV. She described her place and actions; [RW11-114] “... *I can see there the TV was switched off*”. The available data also encouraged her to extend more actions; [RW11-115] “... *one of the children switched it off*”, and thoughts; [RW11-115] “... *I never do that while I am in the kitchen*”, [RW11-116] “... *I always leave the TV switched on even when I am not watching it*” (see figure 7.12).

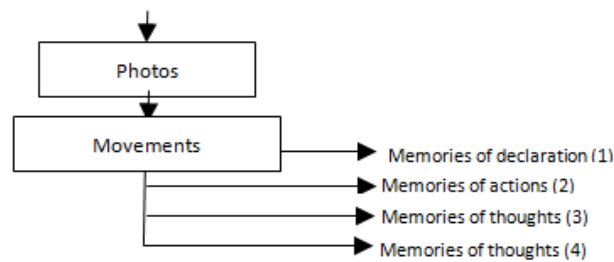


Figure 7.12 Participant (R) Combined the candidate photos with the objects movements.

Participant (R) recognised her place when she combined the photos with her hand and body movements and with the movements of some objects; [RW31-100] “... *I am in the kitchen*”. The available data encouraged her to mention intention and what she was doing at that time; [RW31-101] “... *I was preparing some food for the children*”, and motivated her to navigate forward on the timeline and combine new data. She described her activities on the computer; [RW31-102] “... *I send an email to my sister*”, [RW31-103] “... *I uploaded some photos to my account*”, and then she cited thoughts; [RW31-103] “...*my sister in her email asked me to add some new photos on my page.*” (see figure 7.13).

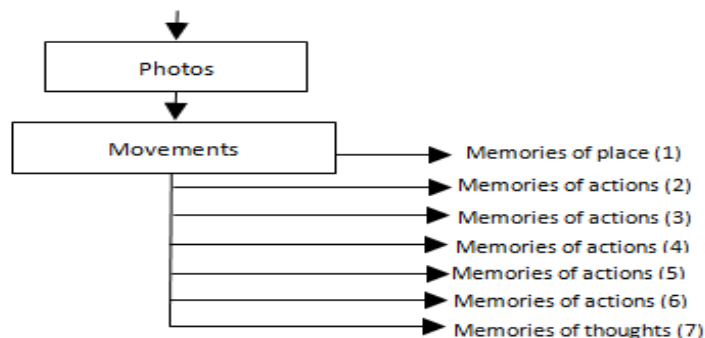


Figure 7.13 Participant (R) Combined the candidate photos with the objects movements.

Participant (R) mentioned time when she combined the four candidate photos with her hand and body movements and with the movements of some kitchen objects; [RW21-115] “... *I usually cook at this time*”. She spots indications of her place and what she

was doing; [RW21-116] “... *there many significant movements of cooker, fridge, and the microwave over there*”. These indications encouraged her to explore that hour’s data on the timeline and expand her answers. She mentioned actions; [RW21-121] “... *I cooked some traditional food that day ... those photos there show one of them*” (see figure 7.14).

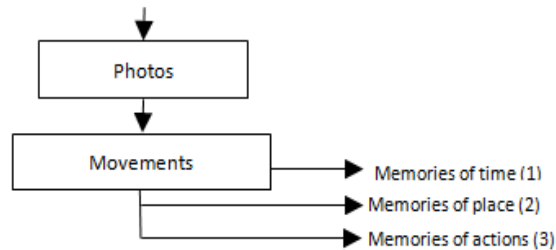


Figure 7.14 Participant (R) Combined the candidate photos with the objects movements.

I found that users often search for the front door movements and then combine them with the four candidate photos to make sure that these movements belongs to them or not. For example, participant (E) searched for the front door movements and then he combined them with the four candidate photos each time that he intended to talk about the time that he left or arrived at home; [EW11- 114] “... *that is my house front door movement*”. He explored his data on the timeline to combine the movements of his hand and body with the photos to talk about his arriving or leaving; [EW11- 115] “... *I arrived just few minutes before seven o’clock.*” (see figure 7.15).

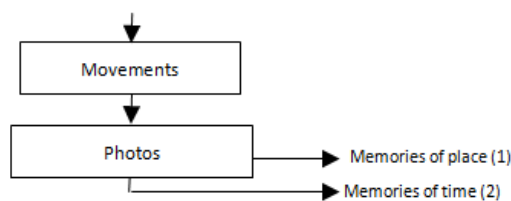


Figure 7.15 Participant (E) Combined the candidate photos with the objects movements.

7.4.1.3 Skimming video to refresh memory

Participant (R) employed playback of the video of multi hours of photos to refresh her memory and to narrow the research period of time. She talked about different places; [RW31-200] “... *This is the main entrance of the restaurant*”. She mentioned her memories of what she thought when she checked the next few photos; [RW31-200] “... *it is not far away from the monument*”. The available data encouraged her to cite her feelings and emotional state at that time; [RW31-201] “... *I was confused*”. She described the action and activities more when she watched the video again; [RW31-202]

“... *I kept silent when the waitress asked me about the food ... we ordered the same PIZZA*” (see figure 7.16).

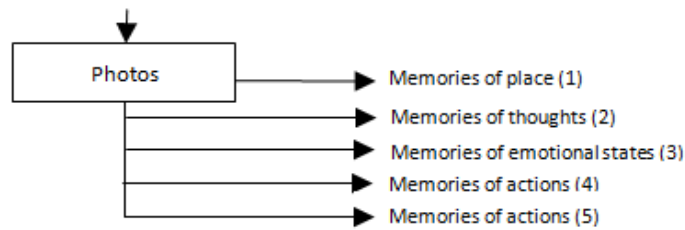


Figure 7.16 Participant (R) Skimmed video to refresh her memory.

I found that users sometimes played back the video of their photos when they were unsure and needed to refresh their memory. For example, participant (R) played back video of an hour when she found herself uncertain whether that hour’s data included the event she wished to discuss. She paused and navigated forward and backward through the video many times before exploring her data on the timeline and describing her actions and activities; “... *child A was watching TV, and child B was playing games*”. Participant (E) described activities as he played back video of an hour photos; [EW32-53] “... *Here, Khalid joined me, we had a lunch together*”, [EW32-54] “... *we sat in the opposite side of the park*”, [EW32-56] “... *I spent a long time waiting for him to come*”. In addition, it was observed that users’ sometimes played back multiple hours of video before locating any indication of their target goal. They often navigated forward to the next hour and repeated the same procedure. For example, participant (R) played back video of the first hour that contained relevant photos and then she navigated to the next hour and did the same until she saw an indication of her target goal; “... *this photo shows ... she still wearing her pyjamas*”. Furthermore, users sometimes played back video of multi hours just to narrow their search to a period of time. For example, participant (E) navigated to a specific hour and played back video of that particular hour’s photos but when he found it was not the appropriate hour he navigated forward to the next hour and did the same until he found a clue indicating his target goal.

Participant (R) played back video of a particular hour to search for a lunch event. She did not find any indication that she had lunch at that time but she found some photos that showed her guest; [RW11-128] “...*I think, we have guests that day*”. She remembered her guest had never visited before then. She mentioned her guest called her in the morning; [RW11-129] “... *she called me morning*”. She navigated backward and searched for that phone call. She mentioned conversations when she combined that

phone call information with the photos; [RW11-130] “...*she told me her Mum would like to visit me*”. She returned back to the previous point in the data when she finished discussing the phone event and continued her search for the lunch. Moreover, users could talk about some memories, such as emotional states and behaviour, that were never captured by any of the devices when they played back the video of the photos. For example, participant (R) mentioned actions and described activities that did not implicitly exist in the photos; [RW12-30] “... *they did not stop talking while they were eating their food*”, [RW12-31] “... *she does not eat anything*”. I found that users sometimes intended to playback the video instead of using a timeline to search for the particular event. This action could allow them to arrive to their target goal easily and faster than using the timeline. On the other hand playback video is sometimes powerless to support users in describing some of their events for three main reasons. First, when there is a gap in the photos. Second, when there is a series of blurry photos. Finally, the memories that are not captured by any devices and need a combination of multi data to trigger memory. For example, participant (R) could not describe some events when he played back the video of an hour. I remarked, when she became silent and paused, that she navigated many times backwards and forwards, but when she explored that hours data on the timeline she become very excited whilst describing what happened. She combined the available photos with her hand and body movements. She mentioned conversations; [RW12-74] “... *they asked me to borrow that book ... the girl said that book similar to one she saw in her school library*”. She added thoughts; [RW12-75] “...*the boy changed his mind when he found his favourite book*”. She motioned time; [RW12-76] “... *we spent a quite long time in the library*”.

I found that users sometimes playback video of an hour(s) just to confirm the occurrence of an event(s). For example, participant (R) played back video of an hour to confirm the kids did not go to school that day. She navigated to the time that the kids were supposed to be at school and she stopped her searching when she located the first photo showing the kids at home; [RW12-125] “... *the boy was watching TV, and the Girl was playing the games*”. In addition, users sometimes playback video of selected hours of the day to refresh their memory and to make a basic plan of where and how to search for other data.

For example, Participant (R) played back video of multiple hours before answering any questions and then she moved back and combined the four candidate photos with the front door movements to locate the expected time of her target goal; [RW31-147] “... *we did not spend a long time in the house ... we went out*”. (see figure 7.17).

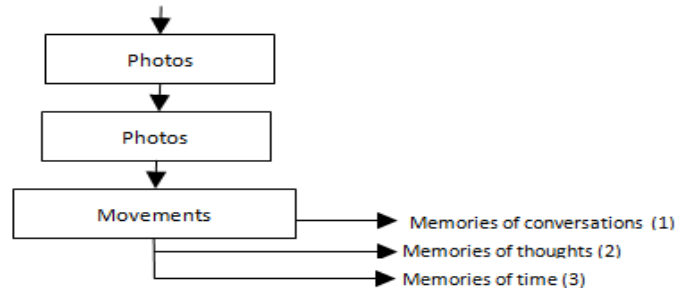


Figure 7.17 Participant (R) Skimmed video to refresh her memory.

7.4.2 Cross-sensor-jumping

I found that graphical movements were very useful in helping users to search, locate and navigate to their new action or activity as well as segment and group their data into a component event. For example, the main door movements allowed users to navigate to that period of time and combine that movement with the photos to talk about actions and activities that happened at that time; [EW11-19] “... *I returned back to my house ... that’s the front door movement*”. In addition, the information and memories obtained from one step could be used to encourage users to move forward and combine more available data about that event and extend their talk. For example, participant (E) talked about the weather status when he combined the virtual Google earth data with his hand and body movements; [EW11-23] “... *it was a little bit cloudy, the phone captured the GPS signal after approximately six minutes*”. He cited his intention and he mentioned some conversations that he had with the kids on the journey as he followed his path on the map; [EW11-25] “... *my daughter asked about the reason of doing that, I did not find a good answer for her*”. Furthermore, few movements could support their users memory unless combined with any other data, and this encouraged users to combine more data to find the reason of this. For example, participant (E) described an event when he found no hand and body movements and almost all of the photos were the same; [EW11-28] “... *No movement for more than ten minutes ... I was looking at a magic show in the height street*”. He cited his feelings and emotional state; [EW11-28] “...*It was wonderful ... many children were happy*”.

Later in the data collection and analysis process, when trying to make sense of events, users utilized a combination of *bookmarks* and their own intuition or innate knowledge as a tool to navigate through and narrate the events themselves. The participants would look across the different streams of data on the timeline, looking for particularly exceptional markers in order to further their story. For example, participant (E) jumped into the next period of time containing noteworthy movements of his hand and body to find and describe the next event. He wanted to discuss “... *we moved when the bus arrived ... I did not stop moving my back stand*”. The available data encouraged him to travel mentally back in time. He cited some thoughts; “*the bus chair was not comfortable at all... the first two drivers drove very smoothly, but the last one does not*”.

It is also interesting that the memories of the physical aspects of the event are elicited by the sensor data. In another case, participant (R) recalled the start time of an event when she combined the photos with the first objects’ movements. She described her place and activities at that time; “... *I left the TV working when I was in the kitchen ... nobody was watching the TV*”. There are two main uses for multi-sensor-jumping that users apply to locate and talk about their events. These are.....

Participant (E) described actions and activities when he located the log movements of his hand and body and combined them with the photos on the timeline; [EW11-98] “...*I can see there the movements stopped for few second and then started again,*”. He mentioned places; [EW11- 99] “...*those photos show we are outside of the culture lab building*”, [EW11-101] “... *that photo show we were in the electronic shop*”, and he cited his feelings and emotional state; [EW11-102] “...*he was confused about the prices, he cannot decide which one to buy*”.

I found that users sometimes navigated on the timeline to search for a lack of hand and body movements to locate the next event and then they would combine the lack of movement with the photos of that period of time to describe their past actions and activities. For example, participant (E) combined a lack of movement with the screen images to track and monitor his actions and activities on the computer; [EW12-105] “... *here, I was checking my email’s Inbox ... there, I was working on my thesis document...*”

I found that photos that were captured with no body and hand movements differed from those captured at moving time. The former could tell us that it was something interesting in front of the users, especially when they spent more than 30 seconds looking at something, which means that the complete scene would be stored in long term memory and that memory could be retrievable. For example, participant (E) mentioned a different memory that did not appear explicitly in his data when he combined the photos with none movements; [EW31-71] “... *I stopped there ..., I was looking at the statue of the queen mother ... I have been there many times ... many tourists were there*”. He cited this new place and actions when he navigated forward on the timeline and located a new period of time which lacked hand and body movements; [EW31-73] “... *those photos were taken at the bus station ... we arrived just 10 minutes before the departure time ... I did stop moving in the bus station ... I met Mike with his girlfriend there*”. He mentioned his intentions when he moved forward on the timeline and saw his hand and body movements; [EW31-74] “... *we are on our way to the bus*”, and he added some actions and cited some conversations; [EW31-74] “... *that woman was talking to me ... she asked me to swap with her ... she likes to sit with her group*”.

7.4.2.1 Jump out to talk about related event then jumped back

Users navigate forwards or backwards on the timeline to locate and access indicators that are related to their current event to extend (or complete) telling their narrative of an event, before then returning back to the original place in the timeline to continue their search and talk about the next event. For example, participant (E) navigated backward on the timeline to talk about an SMS that he mentioned during his talk. He cited the sender name and the contents of the SMS.

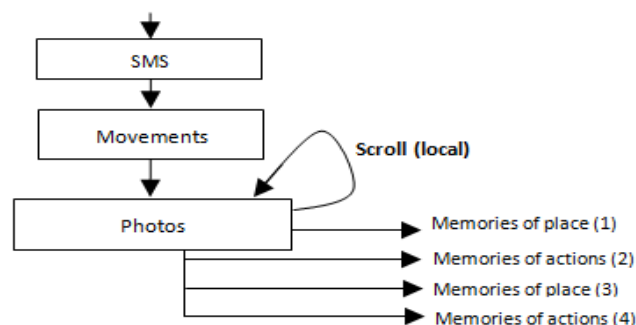


Figure 7.18 Participant (E) jumped out to talk about related event and then jumped back.

He described his place when he combined the SMS with the photos and with his hand and body movements; “... *that SMS I received when I was in the shop*”.

He went on to discuss his intentions and what he was doing; “...*I bought some stuff from their*”. He returned back to the previous point when he had finished talking to locate the subsequent photos, which he combined with his body and hand movements to describe the following actions and activities. He talked about places; “... *those photos were captured in the Hyde Park*”, and describe what he was doing at that time; “... *here, I was sitting, neither body nor hand movements*” (see figure 7.18).

Participant (R) played back video of a particular hour to search for a particular lunch event. She did not find any indication that she had had lunch at that selected time, but she found some photos showing her friend. The data encouraged her to remember a phone call she received from her friend and she navigated backward to locate that phone call. Describing it, she mentioned the time when she combined the phone call with the photos; “... *Sue called me at morning*”. She mentioned some conversations; “... *she told me her Mum would like to visit me*”.

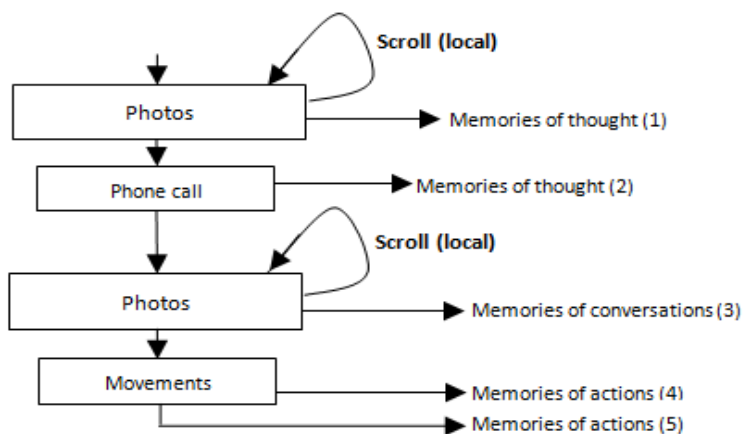


Figure 7.19 Participant (R) jumped out to talk about related event and then jumped back

After talking about that phone call she returned back to the previous point on the timeline and continued to talk about her lunch. She relied on multiple sensors to jump to her target data. She searched for some objects' movements. She described actions; “...*there, I can see the movements of the cooker, the fridge, and the microwave*”, she described her actions in more detail when she navigated forward on the timeline and combined the objects' movements with the photos and with her hand and body movements; “... *I cooked food that day ... those photos there show I was cooking some food*” see figure 7.19).

7.4.2.2 Jump to specific times

Users often navigated forwards or backwards in time to access specific points of their daily routine such as time of work, school, exercise, breakfast and lunch. I found that daily routines could encourage users to identify specific hours to search that could include their target goal instead of searching multi hours to achieve this. In addition, this allowed them to generate a retrogressive search by ‘jumping’ away from and then returning to the previous point to continue their searching. For example, participant (R) jumped backward to the hour that she expected she had a lunch at and then she navigated to the next one when she found none of the four candidate photos related to that event. She navigated to the next hour and did the same, finding that the first candidate photo showed some food. She mentioned some thoughts; “...*they just drunk their hot chocolate with some biscuits ...they did that many times... they refused to eat any food at that morning ... the boy started first and then his sister followed him*”.

I found that daily routines could allow users to bypass time and navigate directly to the hour closest to that which could include their target goal. For example, participant (R) restricted her target goal in between two hours; [RW22-148] “...*we always had a supper at 7 or 8 O'clock night*”. She did not care about the four candidate photos, but she directly played back video of the first hour. She explored that hour’s data on the timeline and combined the photos with her hand movements and with the movements of kitchen objects. She mentioned place; [RW22-150] “...*all photos here show me in the kitchen*”, and she described what she intended to do; [RW22-151] “...*I was preparing some food*”, [RW22-152] “... *here, I am cooking*”. The available data encouraged her to cite thoughts; [RW22-153] “... *it was the first time I cook that kind of food*”, [RW22-154] “... *one of my friends cooked for me when she invited me to her son birthday party*”

Participant (R) navigated straight away to a specific hour and combined the four candidate photos with her hand and body movements. She moved forward to the next hour when she found no indication of lunch at that time. She explored that hours data on the timeline and described her actions and activities; [RW22-35] “... *they did not finish their food ... they did that many times this week*”.

7.4.3 Continued Scanning

The continued scanning strategy was employed to make sense of data at the finest level. Users would employ the strategy last when making sense of extremely detailed data sets. Users tended to apply continued scanning to satisfy the following needs.

7.4.3.1 Continued scanning for more support

Users' continued their forward or backward scanning on the timeline whenever they needed more support from their data. For example, participant (E) mentioned actions and activities when he combined the photos with his hand and body movements on the timeline; "... here, I am sitting, neither body nor hand movements... here, my friend joined me... he went back to his office ... I spent a long time waiting for him". He cited time; "... we had a lunch together ... that is some of our food there", he mentioned thoughts; "... I can remember the rest of the food which are not appearing in the photos", and he cited his emotional state; "... I can remember my feelings at that time" (see figure 7.20).

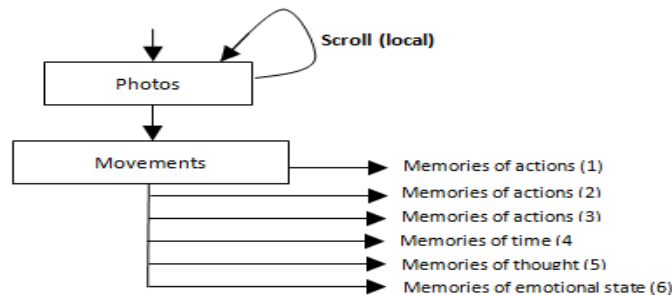


Figure 7.20 Participant (E) applied Continued Scanning for more support.

I found that continued scanning could support users when describing memories that were not captured by any devices when they joined their data together on the timeline.

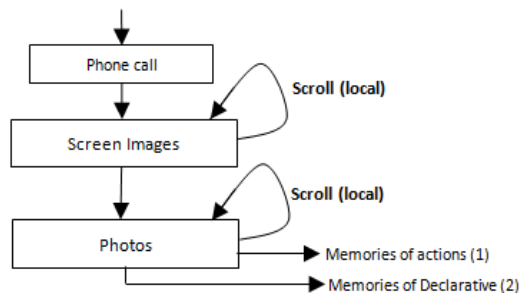


Figure 7.21 Participant (E) applied Continued Scanning for more support.

In addition, users scanned their data to describe actions that happened before or after a specific event. For example, participant (E) described what he was doing when he received one phone call.

He continued his navigation forward on the timeline and combined that phone call with the screen images and with the photos to mention activities on his computer; “... *that image shows I was checking an email ... it was from my friend*” see figure 7.21).

Participant (E) navigated forward on the timeline and combined the photos with the movements of his hand and body to. He mentioned time and described places; [EW11-63] “... *those photos show space 10 ... we went to the Kitchen for lunch*”. He cited people’s names; [EW11-66] “... *Sue was there he had a lunch with us as well*”, and he mentioned some conversations; [EW11-68] “...*Sue said his housemate thought he plan to do a party when he saw him carrying a dozen of pizza*”.

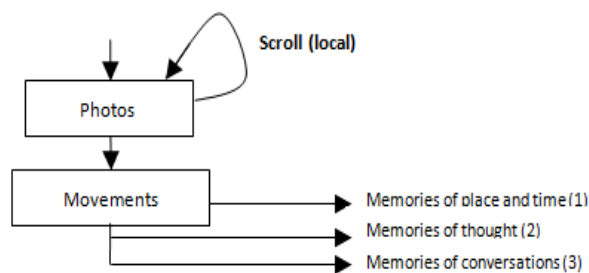


Figure 7.22 Participant (E) applied Continued scanning for more support.

Participant (E) described an event without checking his data; “... *I can remember exactly what happened at that moments ... one bicyclist passed in front of us... he did not stop ... he nearly hit us*”, but when he navigated backward and combined the photos with the log movements of his hand and body he yelled “...*Oh my God, the traffic light was red when we crossed the road ... we were talking ... we did not see the traffic light*” see figure 7.22).

Participant (E) described what he was doing when he continued his forward navigation on the timeline and combined his screen images with the photos and with his hand and body movements. He mentioned activities on the computer; [EW31-195] “... *that image shows I was checking an email ... it was from my friend my friend*” .He talked about the email’s content when he navigated backward to that email; [EW31-196] “... *my friend asked me about academic acceptance from the University for his brother ... he wrote his brother English is not very well ...*”. He navigated forward on the timeline and searched

for his reply email; [EW31-199] “... *I could not find any reply in the next few hours*”. He mentioned he was certain about his reply email; [EW31-200] “... *I replied him at night*”. When he moved back to the previous point on the timeline and continued talking, he added more thoughts; [EW31-201] “... *I was very busy that day... I used the home computer to replay my friend email*” (see figure 7.23).

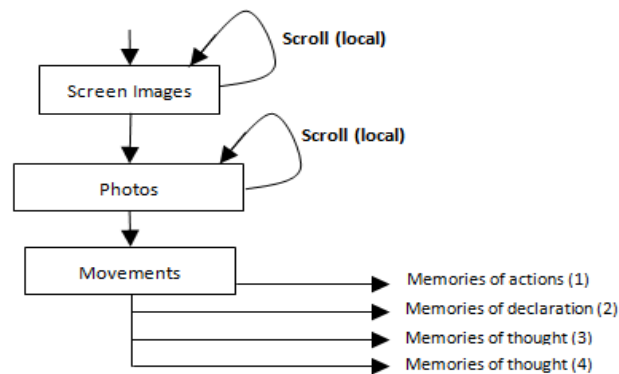


Figure 7.23 Participant (E) applied Continued scanning for more support.

Participant (E) navigated on the timeline and combined the first screen images with the photos on the timeline. He described the contents of the images; [EW32-205] “... *those screen Images show I was checking my email Inbox*”, he mentioned the sender; [EW32-206] “... *that email I received from the community*”, and then he cited the subject of that email and his thoughts; [EW32-207] “... *It was the normal meeting to discuss the community’s issues*”. He added more activities when he navigated forward and combined more images with photos in timeline; [EW32-208] “... *there, I was serving the internet*”, [EW32-209] “... *those screen images show, I was reading a paper*” (see figure 7.24).

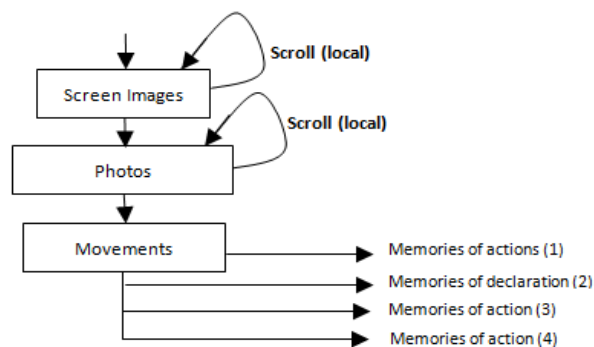


Figure 7.24 Participant (E) applied Continued scanning for more support.

Participant (E) was not sure when within the hour period an event had occurred when he combined the graphic line of the screen images with the four candidate photos. He explored that hour's data on the timeline and then he mentioned actions when he combined the screen images with the photos and with the log movements of his hand and body; [EW32-136] “... *those photos here showing me watching my son playing game on the computer*”.

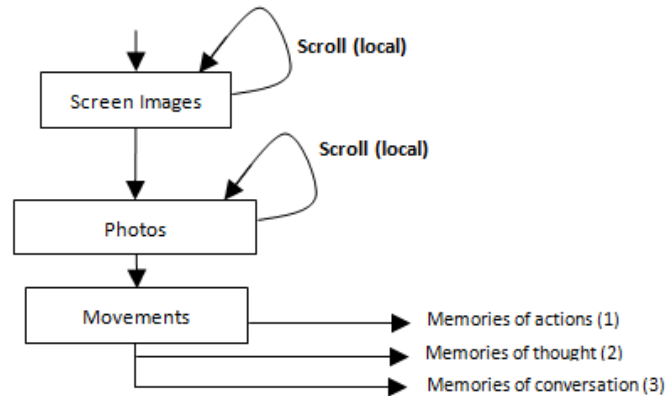


Figure 7.25 Participant (E) applied Continued scanning for more support.

The available data encouraged him to mention thoughts; [EW32-138] “... *the game was very hard and each time he was calling me for help*”, and he described conversations he had had when he navigated forward on the timeline; [EW32-138] “... *I asked him to watch cartoon DVD's, but he instead of the games*” (see figure 7.25).

7.4.3.2 Continued scanning to search in-depth

I found that users applied continuous scanning to search their data in-depth and refresh their organic memory (OM). Participant (E) described memories that did not exist explicitly in his data collection when he combined the photos with his hand and body movements on timeline. He mentioned place and people's names; “... *after approximately seven minutes Tom, Dick and Harry arrived at the bus station*”. He mentioned some conversations; “...*we talked about the Libyan civil war ... situation and the expected future*”, and he described emotional states; “... *one of them was disappointed*”.

He carried on talking when he continued his scanning and associating more data. He mentioned his intentions and his destination when he saw his path on the virtual Google earth; “... *it was another alternative short route to our destination*”. He cited the weather status at that time; “... *it was a sunny day and the sky was clear*”. In addition,

when he combined the data presented on the virtual Google earth with the data available on the timeline he talked about places that he visited; “... *those photos captured in the Hyde Park*”. He mentioned some conversations; “... *he told me about the <anonymised>, and about the olive tree*”. He described his emotional state; “... *it was big surprise for me... I could not believe my eyes ... I shouted, olive tree in London*”, and then he cited many of his thoughts; “... *I saw that woman with her husband in the embassy... we did not sit on the chairs, they were wet*”.

Participant (E) described in detail one of his journeys when he navigated forwards on the timeline, combined with the photos, the log movements of his hand and body and with the data on the virtual Google earth. He mentioned a place; [EW31-282] “... *here, I am on the bus, the street was clear*”, and the movements and the blurry photos encouraged him to mention thoughts; [EW31-283] “...*the bus driver hit the car in front of us at the traffic lights*”, [EW31-284] “... *the driver of the other car did not stop and did not take to the bus driver*”.

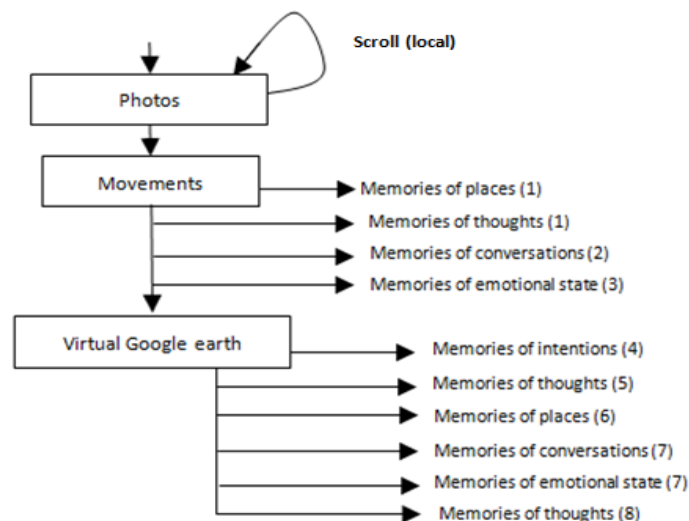


Figure 7.26 Participant (E) applied Continued scanning to search in-depth.

Participant (E) cited his place when he combined the photos with his hand and body movements; [EW21-59] “...*those photos taken in the lift*”. He mentioned other places when he combined the virtual Google earth data with the log movements of his hand and body; [EW21-61] “... *those photos captured at Tyne bridge*”, He described the next actions and intentions when he navigated forwards on the timeline; [EW21-62] “... *I went to the Tesco shop to buy some food*”. He mentioned a phone call; [EW21-62] “... *that phone call was to my friend*”. He mentioned what he bought from the shop when he pointed to some photos showing the trolley; [EW21-64] “... *those photos show the*

trolley and almost of the stuff that I have been bought from the shop”, [EW21-65] “... here, I am checking out at the shop”, [EW21-66] “... that photo shows the checkout machine” (see figure 7.26).

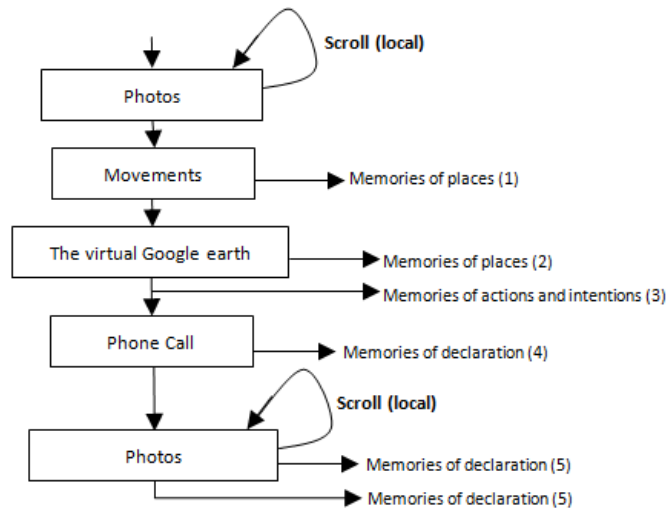


Figure 7.27 Participant (E) applied Continued scanning to search in-depth.

Participant (E) mentioned some of his activities on the computer when he combined the screen images with the photos and with the log movements of his hand and body; [EW21-127] “... *I opened my diary and I found I have hospital appointment*”. He mentioned thoughts; [EW21-129] “...*I missed two appointments before that one ...*” and cited more activities when he navigated forward and combined more data; [EW22-80] “...*I spent the whole of that day working on that document and skimming some papers*” [EW22-82] “... *I checked my email and the news many times*” (see figure 7.27)..

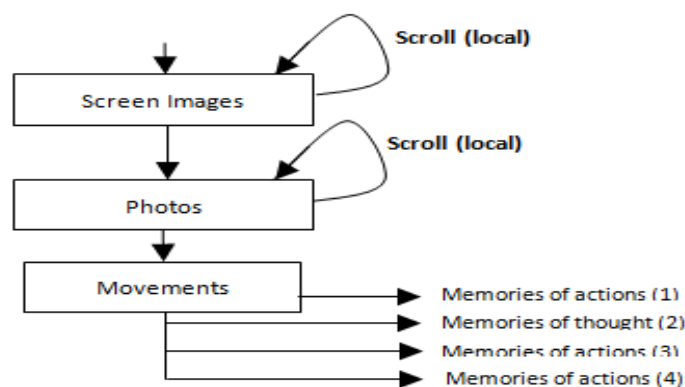


Figure 7.28 Participant (E) applied Continued scanning to search in-depth.

Participant (R) distinguished her screen images from the kids’ images when she combined the screen images with the photos and with the log of her hand and body

movements; [RW21-230] “... *I turned left the computer for the children to watch cartoons video*”. The data available encouraged her to mention conversation; [RW21-231] “... *they told me, they had already watched that video at school*”.

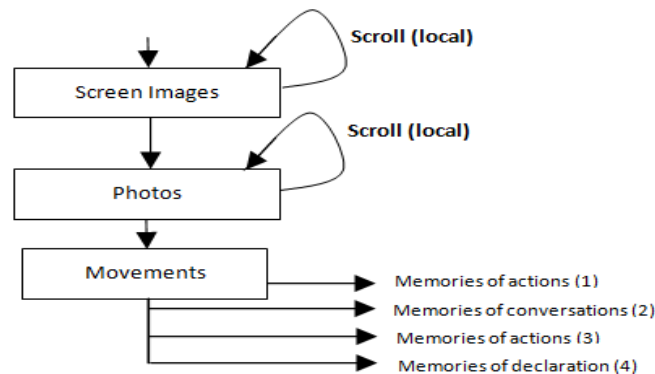


Figure 7.29 Participant (R) applied Continued scanning to search in-depth.

The combination of the screen images and the photos allowed her to locate the first image that belonged to her. She cited some activities; [RW21-233] “... *I checked my email Inbox*”, [RW21-234] “... *there, I can see the sender name and the subject ... It was from my big sister*”. After she checked its contents, she added more details ; [RW21-235] “... *she sent me some of her family photos*” and described her thoughts; [RW21-236] “... *the boy was very small last time I saw him*” (see figure 7.28).

7.4.3.3 Continued scanning to complete telling a story

Users often continued scanning to complete telling a story by combining more data on the timeline. Participant (E) mentioned places when he combined the photos with his hand and body movements; “... *when I checked the photos of that time I found many of them show the Haymarket metro station*”, and then he mentioned the people he met there; “... *that photo shows my friend ... he was talking to me*”.

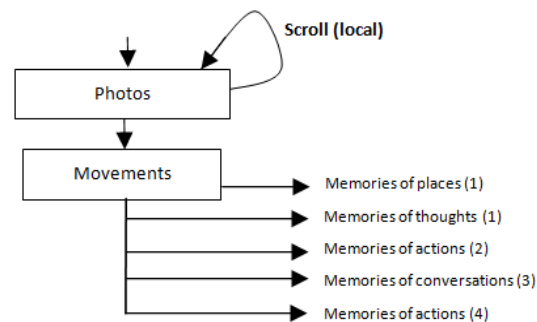


Figure 7.30 Participant (E) applied Continued scanning to complete telling a story.

This data encouraged him to move forwards on the timeline to combine more data and describe more actions and activities in detail; “... *I stopped there to have chat with him*”.

He mentioned some conversations; “...*few weeks ago he told me about his visa...he asked me to help him to fill-in the application ... I told him he can to my office at any time...*”. He mentioned more actions and activities when he navigated forwards on the timeline and combined the photos with his hand and body movements; “...*we walked together to the culture lab... I invited him to my office*” (see figure 7.29).

Participant (R) combined the next photos with the log data of her body and hand movements on the timeline to finish talking about shopping with her friend. She mentioned different places; [RW31-206] “... *we went to the Eldon Square ... those photos shows we are in the shop*”, and she described many actions and activities; [RW31-207] “... *my friend recommended me one shoes*”, as well as thoughts; [RW31-207] “... *it is very beautiful... I did not find my size*”, [RW31-208] “...*the shop sells high quality coats as well*”, [RW31-209] “... *the price was very height*”, [RW31-210] “... *we found ourselves far away from the monument Metro station*”. Finally, she mentioned conversations; [RW31-209] “... *my friend said she lost many times and cannot get out easily from Eldon Square*”, and her emotional state [RW31-211] “... *I was very tired, but I was very happy to get*”.

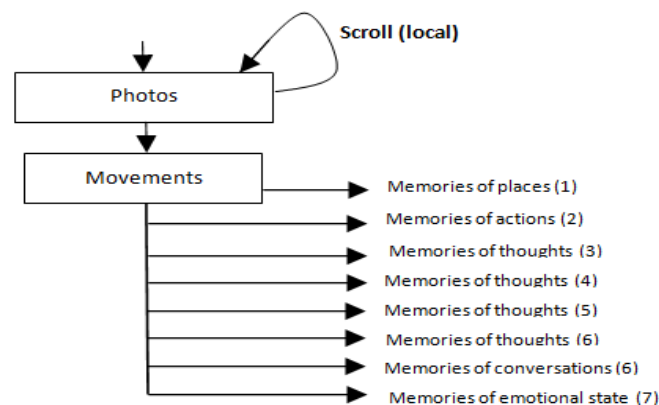


Figure 7.31 Participant (R) applied Continued scanning to complete telling a story.

Participant (E) combined the photos with the movements of his hand and body. After which he talked about places; [EW11-143] “...*I walked to Gateshead bank*”, [EW11- 146] “...*that photo captured inside the bank, it shows the banker face*”, actions and the reason for being there; [EW11- 144] “... *I requested new bank statement to*

renew my visa”, and he expressed his feeling and emotional state [EW11- 145] “...*that man is very friendly ... he always smiling*”. He described the whole journey - his path, intentions and destination when he combined his hand and body movements with the data on virtual Google earth; [EW11- 149] “...*The path on Google earth shows my destination*” (see figure 7.31).

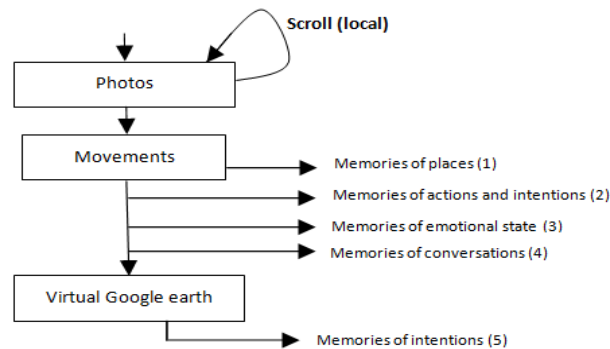


Figure 7.32 Participant (E) applied Continued scanning to complete telling a story.

Participant (R) did not stop talking and continued to navigate forward on the timeline when she found many photos showing a woman in front of her. She mentioned actions and activities; [RW21-54] “... *that photo shows the woman typing my number on her mobile*”, and she cited conversations; [RW21-55] “... *the woman said she has been in my country for many years*”, [RW21-57] “... *she said she graduated from there, and she still has connection with many of her schoolmate*” (see figure 7.32).

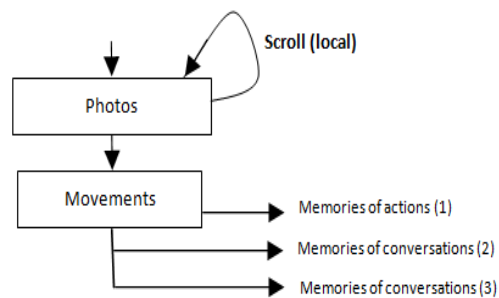


Figure 7.33 Participant (R) applied Continued scanning to complete telling a story.

Participant (E) mentioned the caller’s name and some conversation when he navigated forward on the timeline and combined the phone call information with the photos, with the movements of his hand and body and with the virtual Google earth data; [EW32-78] “... *when that man saw the camera flashing, he asked me “what is that?” is that a camera? ... I said, yes ... it’s a camera and I am filming you now ... he said okay twice*”

and run away”, [EW32-80] “... my wife asked me about that ... I told her the story”. He cited his emotional state; [EW32-80] “... I laughed too much”.

Participant (R) mentioned actions when she combined the photos with her hand and body movements; [RW12-58] “...there were two girls playing football in the park”, and thoughts; [RW12-58] “... one of them studying at the same school of my son”, [RW12-59] “...I saw her with her mum many time”, [RW12-61] “...we had an English course together one year ago”, [RW12-62] “...I have not seen her for a long time”. Also, she described emotional states; [RW12-59] “...her mum is friendly woman ”, [RW12-60] “...she always smiling and greeting people”, [RW12-63] “...I felt very sad for her to hear her bad news”, and conversations [RW12-62] “... she told me about her divorce”, [RW12-64] “...she said it was her decision” (see figure 7.33).

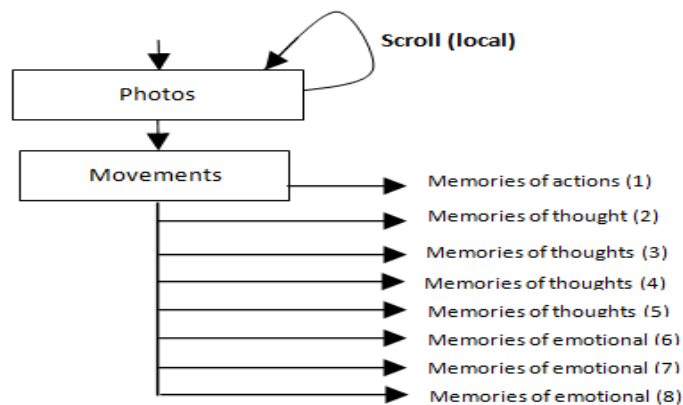


Figure 7.34 Participant (R) applied Continued scanning to complete telling a story.

7.4.3.4 Continued scanning to refresh the organic memory

I found that users continues their scanning even when they were unsure what they might find. Participant (R) searched for conversations although she knew that there is no such data in her collection. She mentioned some when she navigated forward on the timeline and combined time, place and people together. In addition, she mentioned memories of emotional states; “... they enjoyed their new toys... not one of them bothered me.” Furthermore, participant (E) searched for phone call conversations when he combined the photos with the phone call information and also with the movements of his hand and body; “... he told me his son is sick and they planned to take him to...”. He also described his emotional state at that time; “... I was very sad to hear that”.

Participant (R) combined the photos with the log movements of her hand and body and then navigated forward and backward many timesto search for any other data captured

at that time. She found numerous photos that showed the news channel; [RW21-87] “... *I can recognise the people who introduce the news, but I cannot remember what the news was about*”. In another place, she mentioned a different memory when she navigated forward and backward on the timeline when she found a few photos showing a singer's face; [RW21-88] “... *I can remember that famous singer and her beautiful song*”. She mentioned thoughts; [RW21-89] “... *she was singing for her mother*”, and she described her emotional state at that time; [RW21-89] “... *she has a very nice voice ... it takes me back to my childhood*”, [RW21-90] “... *I felt as living again that moment ... although, I heard that song many times but, I still have the same feeling each time I hear it again*” (see figure 7.34).

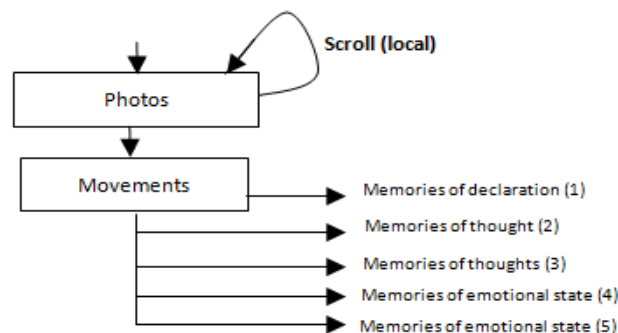


Figure 7.35 Participant (R) applied Continued scanning to refresh her memory.

7.4.3.5 Continue scanning to swap between data

I found that users continue scanning and swapping between data types when they found gaps in the collection. Participant (E) searched the photos instead of the screen images to talk about his activities on the computer; [EW21-237] “...*these photos here show I was searching the internet ... I was looking for a charger for my phone*”, and then he swapped to the screen images when he found they were more relevant; [EW21-242] “... *I can see there, that image shows the complete information of that order*”. He swapped back to the photos when he found a gap in the screen images. He talked about the reason for this and associated intentions; [EW21-245] “... *Bob was looking for LCD display screen for his computer*”, as well as mentioning some thoughts; [EW21-246] “... *he found many, but he could not decide which one to buy ...*”, and some conversations; [EW21-247] “... *Bob told me he received his order within a few days, but it does not work*”. He swapped again to the screen images when they appeared. He talked about an email; [EW21-249] “... *this email here for all computer science postgraduate*”, and he

talked about the subsequent actions when he navigated forward on timeline; [EW21-252] “...*I showed him the application form of the progress report*” (see figure 7.34).

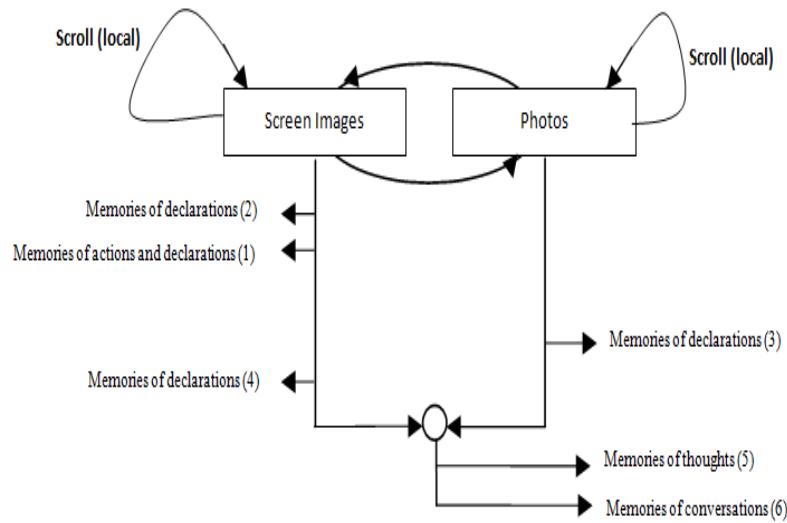


Figure 7.36 Participant (E) applied Continued scanning to swap between data.

7.4.3.6 Continued scanning to monitor almost all of the data in one place

I found that users’ employed continuous scanning to explore their collection in one place. Participant (R) talked about the contents of some photos; “... *that photo shows my phone ... I was checking the GPS signal*”, and the data available allowed her to know the reason why the first photos did not appear on the Google earth and supported her in describing the weather status at that time; “... *the sky was clear*”. She mentioned her destination when she combined the photos with the virtual Google earth data; “... *my destination was Newcastle city centre*”.

Users often preferred to continue their scanning on the timeline and combine as much data in one space to describe their actions and activity. For example, participant (E) described his place when he navigated forward on the timeline and combined the next photos with the phone call information and the data on the virtual Google earth; “... *there, I can see the bus stop on the map*”. This encouraged him to mention some of the phone call conversations; “...*I told her about the painting pictures ... she said, she always doing that ... she has many, but I don’t like them*”. The next photos allowed him to talk about a new place; “... *there, I am in the bus .. I was on my way to the University ... the street is clear ... there were only a few cars on road*” (see figure 7.36).

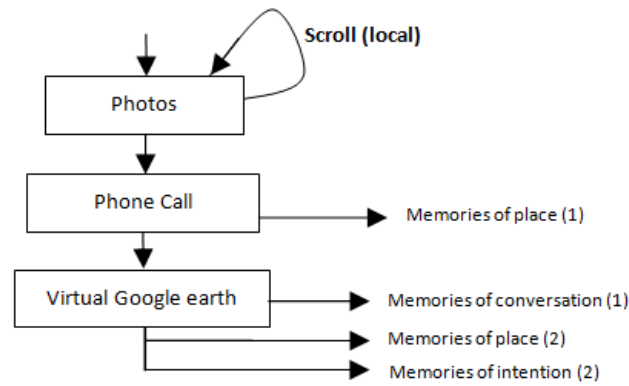


Figure 7.37 Participant (E) applied Continued scanning to monitor his data in one place

Participant (R) mentioned some activities and actions when she combined the screen images with the photos and with the log movements of her body and hand on the timeline; [RW22-290] “...here, I can see my computer screen Images, I was surfing the web”. She talked about her intentions when she navigated forward; [RW22-291] “... I was looking for ice cream maker” and cited her thoughts “... the kids asked me to make some of them at home when they watched the machine on TV show”.

Participant (E) mentioned actions and activities when he navigated forward on the timeline and combined the log movements of his hand and body with the photos and the phone call data; [EW31-125] “... and here, I stopped for short time”. He mentioned the caller’s name; [EW31-127] “... this phone call is from my friend”, but he could not remember anything about the conversation; [EW31-127] “... I could not remember any conversations or the reason of that call”.

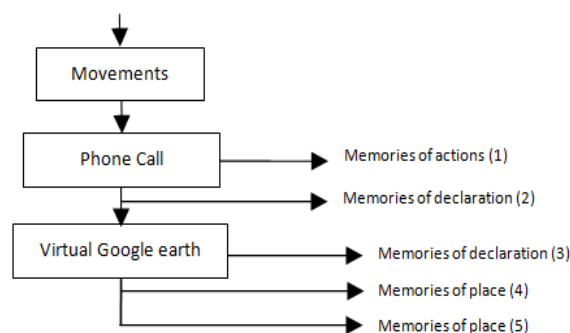


Figure 7.38 Participant (E) applied Continued scanning to monitor her data in one place.

He talked about his path of travel and destination when he moved forward on the timeline and combined the virtual Google earth with his collection; [EW31-128] “... those photos there and the path on Virtual Google earth showing my way to the house”.

He mentioned place when he combined the last photo along the path with the front door movements; [EW31-130] “...*That photo shows the front door of my house*”, [EW31-132] “...*the next photo shows my house stairs*” (see figure 7.37).

7.4.3.7 Scanning to access and combine multiple types of data

I found that continued scanning could allow users to look from a wider perspective on the data and access and combine more than one type of data to talk about different actions and activities. Participant (R) mentioned her intentions when she combined the Google earth data with the photos and with her body movements; “... *our destination is the Haymarket station...*”. She cited thoughts; “... *my friends has an appointment at the bank... we went directly to Haymarket*”, and she described her actions when she navigated forwards and combined the next few photos with her body and hand movements; “... *we stopped there for few minutes*”.

Participant (E) mentioned the place, the caller’s name and the call duration when he navigated forwards along the timeline and combined the photos with the phone call information. He could not remember the reason for that call and conversation; [EW11-55] “...*that phone call was from my friend ... I could not remember the reason of that call.*”, but he mentioned the time and the conversations when he navigated forward and combined the next photos with his hand and body movements; [EW11-60] “... *when he called me that morning he told me about an offer he found*” (see figure 7.38).

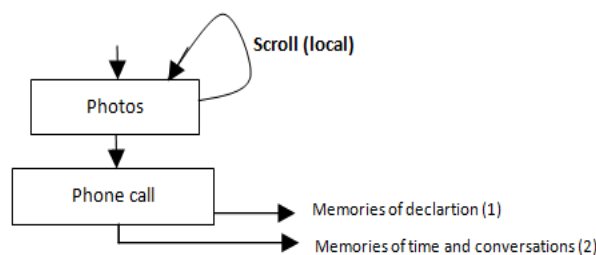


Figure 7.39 Participant (E) applied Scanning to access and combine multiple types of data.

I found that users often prefer to continue scanning their timeline and combine as much data as they could to describe their actions and activities, before navigating to the next event. For example, participant (E) navigated forward on the timeline and combined the next photos with the phone call information and with the data on the virtual Google earth. He described his place; [EW31-279] “... *there, I can see the bus stop on the map*” and the available data also encouraged him to mention some of the phone call

conversations; [EW31-280] “... *I told her about the painting ... she said, she has always drawn and paint at home*”. He continued to describe more actions when he moved forward on the timeline and incorporated his hand and body movements; [EW31-284] “...*those movements there show I was walking*”. He mentioned a new place; [EW31-285]”... *those photos show me in electronics shop*”, describing his reason for being there and his intentions ; [EW31-286] “... *I was searching for an extension for my phone landline*”. Lastly, he cited an action that he did there; [EW31-286] “...*that is the one I bought*” (see figure 7.39).

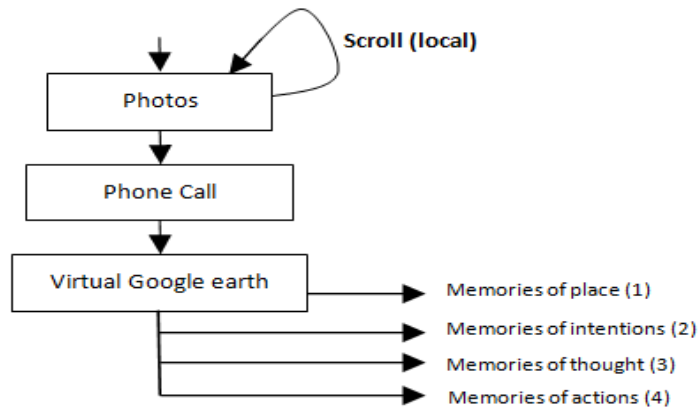


Figure 7.40 Participant (E) applied Scanning to access and combine multiple types of data.

7.4.3.8 Continued scanning to fill the gaps

When the users found data was lacking or there were gaps in the photos they linked the last photos that had been captured before the gap with the first photos taken after the gap and then combined the other types data that were captured inbetween together. For example, participant (R) described her actions and activities when she combined the movements of her hand and body with the last photos taken before the gap and first photo taken after the gap; [RW11-120] “... *that photo shows me holding the kids bath coats and some of their dress*”. The last photos she found on the timeline and the next movements encouraged her to cite actions and thoughts; [RW11-121] “...*yes, I did a shower for him*” and she then talked about the emotional state; [RW11-122] “... *he was very happy to have a shower ... his sister refused that, she started crying when I asked her to have a shower*”.

I found that continued scanning could allow users to bridge and fill the gaps when data was missing on the timeline by combining the other available data captured at the same time. Participant (R) relied only on the movements of her hand and body to describe her

actions and activities when she found gaps in the photos. She talked about the reasons of this; [RW21-40] “... *I forget to wear the camera and turn it on again when we went out of the library*”. She mentioned people she met there; “...*my friends and her daughter were there as well*”. She cited time and action; “... *we had a lunch together*”, and mentioned her conversations; “... *she told me about her new job...*”.

Participant (E) mentioned that he checked the last few photos captured before the gap and the first few photos when the camera was turned on again. He then combined them with the log data of his hand and body on timeline; [EW31-58] “... *when I saw the last photos and first photos that I captured I filled the gap and recalled that period of time in my mind's eye*”. The expression “mind’s eye” refers to the human ability of visualization to recall past events.

Participant (R) found a series of blank and unclear photos on the timeline. She described these events by combining these photos with the log of her body and hand movements and the electricity consumption graph; [RW11-91] “... *we did small birthday party for my son ... those dark photos taken when we turned off the lights and TV*”. She mentioned thoughts; [RW11-92] “...*the children did not stop singing...*”, [RW11-93] “...*their voices were very loud...they repeated the song many times*”, and she described hers and others emotional state at the time; [RW11-93] “... *it was wonderful and amazing*”, [RW11-94] “...*the kids were very happy and excited*” (see figure 7.40).

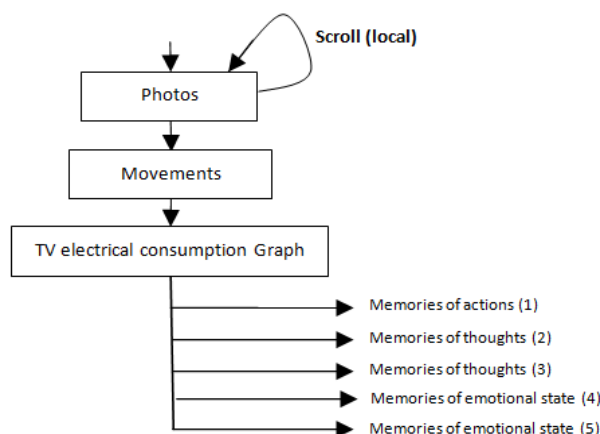


Figure 7.41 Participant (R) applied Continued scanning to fill the gaps

Participant (E) depended only on the movements of his hand and body to continue his narration as he navigated along timeline when he found a very large gap in the photo data. He mentioned conversations; [EW32-194] “...*she said, do not use any media to*

record the workshop”, and he cited thoughts; [EW32-195] “...it was Chinese girl with the speaker ...the Chinese girl works as interpreter to explain some points for the Chinese students”, [EW32-197] “...the first part given by a woman and the second one was given by a man... at the end of the talk checklist was distributed for attendance to be eligible to make appointments” (see figure 7.41)..

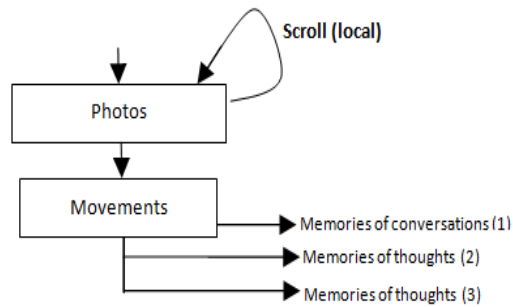


Figure 7.42 Participant (E) applied Continued scanning to fill the gaps

Participant (R) unable to provide any information or description at the beginning of the timeline when she found the contents of the photos nearly the same and no movements of her hand and body, but she mentioned some actions and activities when she navigated forward on the timeline and combined the photos with her movement data and with the electricity consumption graph; [RW11-110] “... I was sitting on the sofa and drinking my coffee”, [REW11-111] “... that photo shows my cup and many photos show the TV...” (see figure 7.42).

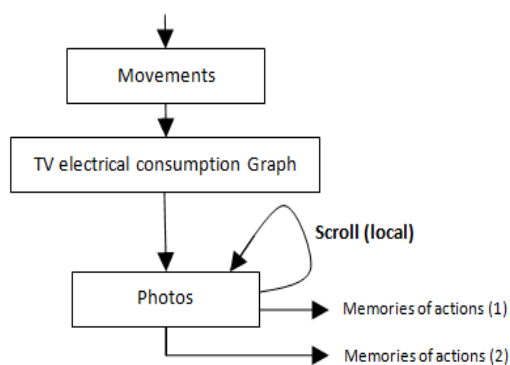


Figure 7.43 Participant (R) applied Continued scanning to fill the gaps

Participant (E) described some of his actions and activities at short period lacking of photos [EW11- 157] “... I went to the hospital appointment ... last photo of that movement shows the stairs of the hospital”. He mentioned the time when he checked

the last photo; [EW11- 158] “...I switched off the camera exactly at 13:00 and I turned on again at 13:43”, and cited his thoughts; [EW11- 160] “...I just waited few minutes to meet the doctor ... I did not use any of the medicine he described to me ... he was uncertain about the side effect of the medicine ... almost of his answers was uncertain”. He mentioned conversations; “...many times he said maybe ... it could be ... I am not sure”, and actions; “...my wife put the medicine in the bin when I told her the story” (see figure 7.43)..

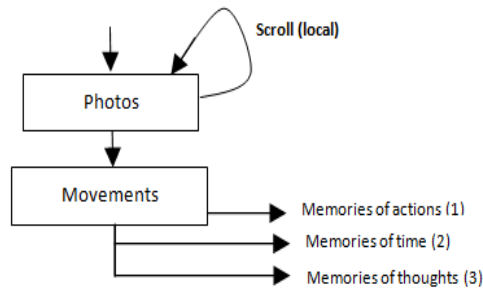


Figure 7.44 Participant (E) applied Continued scanning to fill the gaps

Participant (E) described a number of his activities on the computer when he combined the screen images with the photos and with the log of his hand and body movements; [EW32-145] “... here, I am back working on the computer”. He mentioned what he was doing on the computer; [EW32-145] “... I was surfing the internet”. He switched to the photos and combined them with the electricity consumption graph when he found a gap in the screen images; [EW32-146] “.... those photos there show I moved to watch TV”, and he cited intentions; [EW32-147] “... it was a report about Libya civil war” (see figure 7.44).

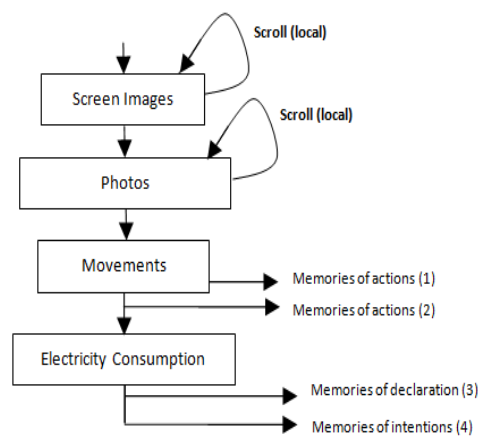


Figure 7.45 Participant (E) applied Continued scanning to fill the gaps

Participant (E) switched to the photos, when he found a gap in his screen images on the timeline, to allow him to finish talking about an event, He mentioned actions; [EW21-135] “...*those photos there show I was talking to one of my colleagues*”, and he cited conversations; [EW21-136] “... *He was asking me about my country latest news*”, [EW21-137]. He also cited emotional states; [EW21-136] “... *he was very happy about the news I told him*”, [EW21-138] “...*I was very happy to see another people care about other problems and share them their happiness*”.

Participant (R) combined her hand and body movements and linked them to the last photos before the gap and the first photo after the gap to talk about a period of time which was not presented in the photos. She mentioned actions and activities; [RW11-120] “... *that photo shows me holding the kids bath, coats, and some of their dress* ”, [RW11-121] “...*yes, I did a shower for him*”, and she talked about emotional states and thoughts; [RW11-122] “... *he was very happy to have a shower ... his sister refused that and start crying when I asked her to do that*”.

7.5 Bookmarks calendar

I found that Participants often search their bookmarks photos before moving to the main calendar and search their hours' data one by one. In addition, they often start their talk by describing the contents of the photos themselves before taking any further action. For example, participant (E) selected the first photo in the bookmarks and described its contents before explore that photo on timeline and combine it with any other data; [EW11-05] “... *that photo shows one boy was talking to my son*”, [EW22-07] “...*the next photo shows John face ... we were in the kitchen*”. Participant (E) described his place when he explored the first photo on timeline and combined the data captured before and after that photo of that period of time; he extend his talk and described memorials that do not explicitly appears in his collection and does not captured by any devices. For example, he mentioned thoughts [EW11-08] “...*the school main gate was closed and many children were outside of the schoolyard with their parents*”, he added reason of being there [EW11-09] “...*they were waiting for someone to come and open the gate*”.

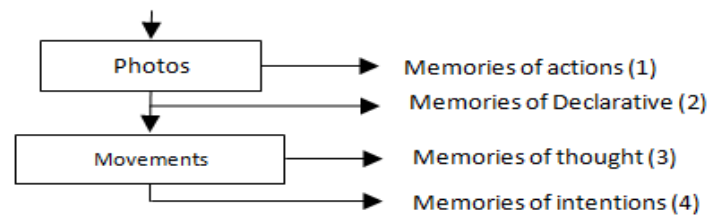


Figure 7.46 Participant (E) uses Bookmarks Calendar to locate memorial

When participant (E) located the second bookmarks' photo on timeline he navigated to the first photo and decried its contents [EW22-11] *"...the first photos show the stairs, my cub and the food bag"* [EW11-11] *"...that photo captured in the kitchen"*, he mentioned time and actions [EW22-12] *"... I had a lunch with Brown at the Kitchen"*, he mentioned some conversations that he had at that time and with whom [EW11-12] *"... Brown told me about his story with the Pizza, he said, he eating Pizza three times a day"*, [EW11-13] *"...it was a big surprise for my home mate when he saw me carrying a dozen of Pizza to the house ... he thought I am planning to have a party"*.

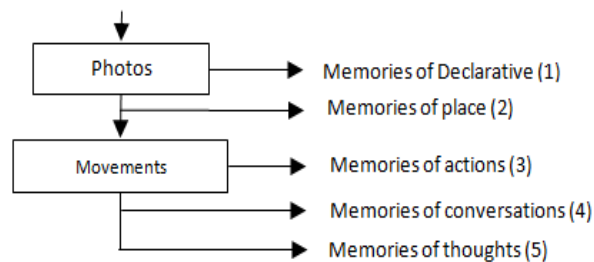


Figure 7.47 Participant (E) uses Bookmarks Calendar to locate memoprial

I found that bookmarks' photos offer a great opportunity to support participants to mentally relive some of their past experience when they watch their photos again and when they combine them with the other available data captured at the same time. In addition, allow them to locate directly specific events such as birthday, anniversary, first day of school, child first step, and Christmas party. Furthermore, bookmarks photos could shrink and summaries users events to allow users to locate their events directly instead of searching their data hour by hour.

7.6 Discussion

One major issue that I have not discussed so far is the ethical implications of lifelogging. The first IsstLog study showed that lifelogging has the potential to intrude upon participants private lives in ways they do not anticipate. The fact that multiple participants felt the need to disguise their activities during this short study, which involved a relatively small number of participants, highlights how prevalent these issues may become if lifelogging is widely adopted. It is clear that, although the participants knew how to limit the collection of data, they did not anticipate when the lifelogging might need to be paused and instead had to destroy the data after its collection. This digital subterfuge was conducted by more than one participant. The outcome of the study also suggests that future lifelogging studies need to allow users to retrospectively, without consultation with researchers, have the option to not simply destroy some part of their data, but to obfuscate it in a way that the researchers themselves cannot detect this occurred.

The second study followed two people in their day to day lives rather than the larger group I had initially envisioned working with. The strategies observed seemed to have certain patterns in their application but statistical analysis of just two participants was not meaningful. However, the results of the second study were interesting for a number of reasons. The accelerometers recording movements of the user's hand and body could allow users to locate and view the beginning and the end of some events easily. Furthermore, it supported them describing events when there were no photos or when the GPS was not able to record the location of an event.

Using the combination of the four candidate photos and hand and body movements supported users by giving them a general idea of where and how they spent their time in a particular hour and helped them to navigate forward or backward to locate the hour their goal was present in. For example, participant (E) navigated to the next hour when he recognized that he was not in the appropriate timeframe. He explored the next hour's data on the timeline where he found some sensor readings relating to his goal and, combining the photos with his body and hand movements, he recalled memories of specific thoughts.

I found that users often focused on the graphical lines of screen images to monitor their working time on the computer. They sometimes could recognise and talk about their time of using the computer, but they could not describe any actions or activities they

performed before exploring the images on the timeline. In addition, combining screen images with other data captured at the same time could support them to expand their descriptions to even mention memories that did not appear explicitly in the data itself. Furthermore, screen images could support users not only to track and monitor their computer activities, but also allow them to talk about their diaries, appointments and social networking actions. Moreover, when the users found a group of screen images that did not belong to them they often used the photos, body movements, hand movements or a combination of these to locate their own screen images. Additionally, although the majority of the information obtained from the screen images were references to declarative memories, but I found it could give the users a clear indication of how they spent their time on the computer. For example, the favourite sites they preferred to visit, when, and for how long.

I found that screen images could cover interesting parts of the users' everyday activities. In addition, information achieved from screen images could support them to remember different types of memories such as emotional state, thoughts, actions and activities as well as declarative memories which were generated from the contents of the images themselves. I believe that following and monitoring actions and activities on the computer could allow the user to reflect, and allow them to manage their time more efficiently.

I saw that TV data was not helpful in many cases, especially when the users often kept their TV turned on throughout the day. However, in some cases it might support users when they describe actions or activities. Similarly, users combined the curtain movements with the photos, but it did not support them in adding any new information related to those movements.

I found that users could learn from their mistakes and attempt to find and apply new strategies that they believe could allow them to find their target goal in a short time, and with less effort, each time they revisit their data. In addition, combining different data sources could support the users' creation of a rich narrative. Lifelogging data not only allowed users to cognitively "travel back in time" to remember past actions and events that happened while actively capturing lifelogging data, but it also encouraged them to recall events that happened days, weeks, or even years before capturing that data. Furthermore, as previous work has also found, the photos of new or rarely visited places provoked more memories than those taken from regularly visited locations. Similarly, a

typical phone call, with the children's school, the hospital, or people who rarely call, were quickly recalled when users spotted the caller name, number and the place of the call and triggered rich narratives. Searching for daily routine actions and events such as breakfast, lunch or work time sped up user searches. In addition, this allowed users to navigate directly to particular times to search them instead of trawling through many hours worth of data.

I found that users could easily find the time when they used their computers, how many times they used it, and for how long when they look at the graphic line of the screen images. On the other hand, they could not say anything about their activities such as how many times they checked their emails Inbox on a particular day, the maximum continuous time they spent on the computer to read one paper, or the time they spent writing a document without exploring the whole data set in-depth on the timeline. In addition, they could not distinguish their screen images from any others before exploring their data on the timeline as well. For example, participant (R) mentioned that [RW31-87] “... *I can see the graphs in many hours' pane, but not all of them were mine*”. Furthermore, combining screen images with photos was the easiest way for users to distinguish their screen images from others; [RW31-89] “... *this graph here shows that the computer used on that hour, but these photos show the back yard of the house*”. Moreover, combining screen images with photos and users body and hand movements could allow them to track their own actions and activities on the computer and give them a clear picture of how they spent their time on the computer.

I found that users often used the log movements of their body and hand as a backbone in their searching and then they combined the movements of that period of time with the available photos to search for any indication(s) or reason(s) to identify their actions. For example, participant (E) mentioned why he decided to walk; [EW32-61] “... *the weather was very nice*”, why he stopped at some place; [EW32-62] “... *I was looking at big Gazelle Statue*”, and why he has been at some other places [EW32-63] “...*I bought some juice and cake*”.

I found that just one email could encourage users to mentally travel back in time and talk about events that happened many days, week, months or even years ago. For example, participant (E) was encouraged by one email to talk about events that happened many years ago; [EW12-50] “...*he has got his Msc degree from Budapest as well*”, [EW12-51] “...*we have been studied at the same University*”, and this also

encouraged him to talk about intentions; [EW12-51] “...*he plan to finish his study in the UK*”, and thoughts; [EW12-52] “... *He works for Petroleum Company*”.

I found that photos taken in newer or recently visited places did not require much effort to recognise or remember. In addition, users could remember extra memories of actions, activities and events when they observed indicators that related to that event, even when there was a lack of photos or no photos at all. Furthermore, some conversation could retrieve when the users continue their scanning and talking to refresh and flash their memory.

I found that users sometimes did not make a plan before starting their search to find the shortest path to achieve their goal. For example, participant (R) used the timeline instead of playback video to search for an event which, consequently resulted in her spending extra time and effort to search multiple hours of data, but at the end the combination of her data supported her to remember thoughts; [RW31-160] “... *It was a long journey; we stuck on the Metro for more than 15 minutes*”, describe actions and activities; [RW31-161] “... *the Metro moved back to the previous stop*”, and talk about the her emotions at that time; [RW31-162] “... *I was very angry of that*”. But I found that they would learn from these experiences and attempt to find and apply new strategies that they believed could allow them to find their target goal in a shorter period of time and with less effort. For example, participant (R) started her search by selecting an hour that she expected to include her target goal and then she played back the video to that hour to be sure of that. Finally, she explored that hour’s data on the timeline to locate the start time of the event. She explored that hour’s data on the timeline and then she started to combine it with the photos and the other available data captured at the same time. For instance, she talked about the TV being on and who was there when she combined some photos with electricity consumption captured at the same time; [RW21-19] “... *first thing they did was watch Cbeebies channel on TV*”, [RW21-20] ... *that is the time when they switched on the TV ...*”.

I found that front door movements could support users to navigate directly to the particular time they needed to search in instead of searching the hour's photos one by one. In addition, it could encourage them to track and monitor their front door behaviour, such as when they often leave and come back to their homes and how often they do that during the day.

Retrieved Memorials

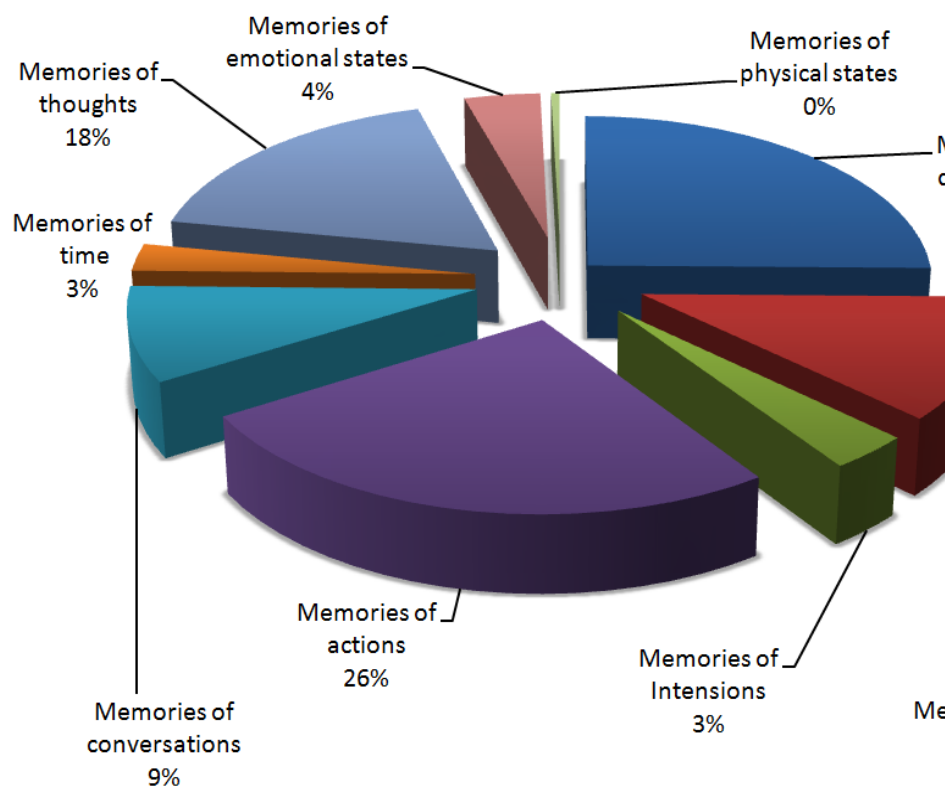


Figure 7.48 Percentages of Different Types of Retrieved Memorials.

I found that, phone calls, emails and SMS's often encouraged users to navigate forward or backward on a timeline to create associations and talk about related data and then return back again to the previous point on the timeline to continue their talk.

I found that users could easily remember conversations of the phone calls they received from school, hospital or from a person who rarely called them, but they could not remember phone conversations of people who called them frequently without effort and combining their data.

Figure 7.45 and 7.46 show that declarative memories represent only 25%. This is what I intended to derive and achieve. My main goal was to employ the lifelogging as an anchor to trigger memory to remember and not to create a memory itself. In addition, Retrieval of memories of actions occurred the most, the main reason for this is the use of the activity recognition accelerometers and electricity consumption meter.

I expected to obtain low values of memories of place and memories of intentions during the observation transcripts and the analysis. I found that memories of intentions were often generated from memories of places which was dependent on the virtual Google earth data. In addition, the virtual Google earth was available only outdoors. My proposed solution for this problem is in chapter 8. The resulting remembrance of conversation provides clear evidence to support the theory that memory is stored almost always visually and audibly and what I need is to access and retrieve those memories.

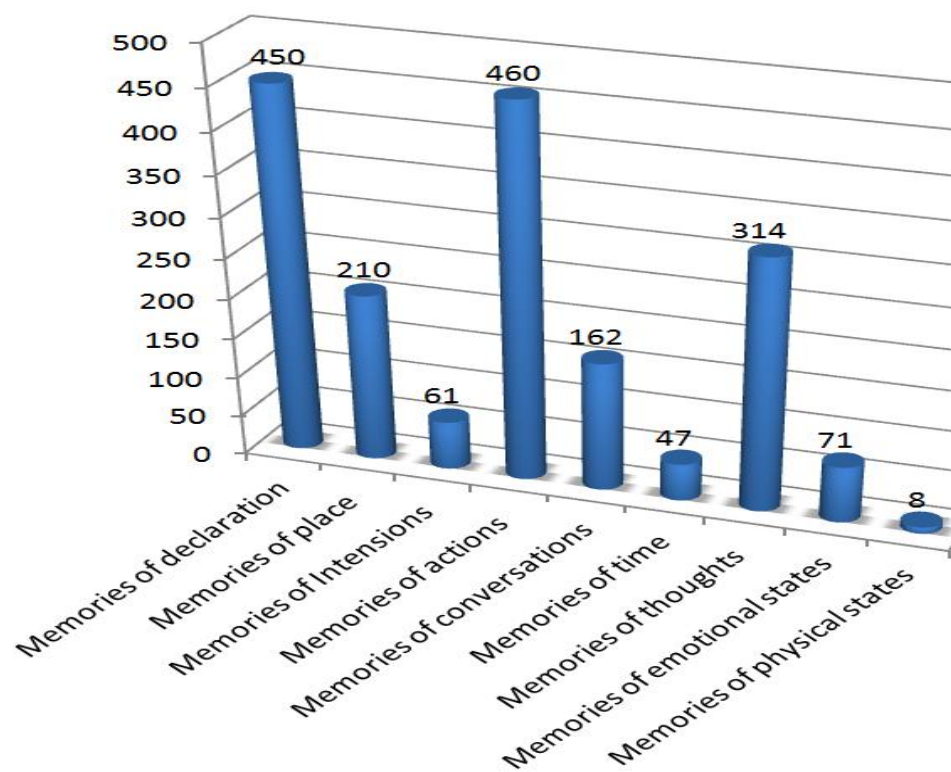


Figure 7.49 Number of times of each Retrieved Memorial

7.7 Conclusion

In this study the notion of Lifelogging technology was extended to include multiple heterogeneous sensor data. The data is perused, controlled and processed using a novel

user interface . This contrasts with the majority of previous systems which adopted only one type of data and presented no real user interface for the data. The system provides a case study of how different types of data can be captured, manipulated and reasoned over. The user study highlights a variety of strategies that people used to pursue, retrieve and reflect upon their past experiences. The results suggest that photos are the most important element of lifelogging ability to support memory, however, the movements of the user's hand and body and the movements of some objects can promote an activity recognition or support user detection and grouping of them into events.

Chapter 8

Conclusion

8.1 Introduction

In this thesis I have investigated how heterogeneous sensor data could support memory by using novel interfaces to control and process it. I adopted two case studies to look at how different types of data can be captured and reasoned over. In addition, I monitored, tracked and investigated different strategies that users followed to create their visual cues. The two case studies allowed me to gain a great understanding of how lifelogging data could support users to retrieve their past experiences. In addition, it also helped me gain insights into how users could employ that data to create their interactive visual cues by following the different steps that they performed on their data. The results suggest that photos are the backbone of lifelogging to support memory, however, the movements of the user's hand and body and the movements of some objects can promote an activity recognition or support user detection and grouping of them into events. In this chapter I conclude the thesis by summarising the main contributions of this work. I also propose some opportunities for future research.

The main objectives of this study were to:

- Develop an increased understanding of human memory and the roles that it performs to manage personal information. What data could trigger human memory and how?
- Develop an increased understanding of lifelogging capture and retrieval tools. These insights could help me to introduce new methods to capture valuable data and metadata from people's environments that could offer the ability to augment human memory.
- Capture individuals' data and their environment metadata with sensors to provide an effective method to store, archive and establish that data as external storage memories.

- Integrate both capture and retrieval of lifelogging technology to support the collection and access of people memories and enhance their lives through new technology.
- Study the use of the interface for accessing the raw data captured from everyday activities and actions, and also to be aware of how people could use it to create interactive cues that are able to augment, trigger and stimulate their memory.
- Design, build and evaluate an intelligent, interactive lifelogging prototype that can be easily mastered and assist people of different ages to create interactive and powerful tools to stimulate organic memory and access past information.
- Discuss, design and implement the prototype functions to make sure that they efficiently perform and work over a long period of time, allowing a great amount of data, representing a large number of memories, to be captured.

These objectives form the structure of this chapter. First, in section 8.2, I outline the thesis overview and research contributions made with respect to each objective. In section 8.3, I express the challenges faced and then, in section 8.4, I propose future work.

8.2 Thesis Overview and Research Contributions

As a part of the research effort in Human Computer Interactivity (HCI) to create effective lifelogging technologies, this research concentrates on collecting meaningful data that could be used to create powerful cues that are able to stimulate human memory for retrieval process and to relive past experiences. In addition, I introduce a novel user interface to present this data visually. The strategy in pursuit of this goal is to build and evaluate new lifelogging systems with real users to assess the value and the usability of each type of data collected as well as the usability of the user interface.

In chapter two I have given an overview of the human memory structure and process. This improves my understanding of the role human memory plays in lifelogging technology, which is the first object of this doctoral work; to establish a clear understanding of how human memory works. In regards to memory structure, I reviewed different types of human memory and also focused on how memory systems

are organised. In regards to memory processing, I have explored how memory and its information is stored and retrieved.

I understand that remembering depends on both the encoding and retrieval processes. In addition, memories are stored, archived and retrieved by combining the information available in the current environment or situation with patterns or cues that have been encoded and stored in the past. This can be initiated by the introduction of cues associated with the memory or by consciously asking questions to aid memory retrieval. Furthermore, I have pointed towards evidence that visual images are valuable cues to stimulate memory to remember past actions and events. Moreover, I discussed that technology could be useful as a memory aid to augment and enhance memory tasks. The review of the lifelogging literature in chapter three started this process by clarifying the relationship between memory and lifelogging technology. It was demonstrated that all lifelogging systems are designed to stimulate different parts of memory to access and retrieve different memories. It was shown that many people needed to retain their past life experience for later use because their memories are unable to handle, manipulate and retrieve their past actions and activities.

I have given an overview of the work carried out previously to examine different memory problems and difficulties that challenge lifelogging technology. Although, lifelogging offers potential benefits to its users, it still faces many challenges. For example, managing, and retrieving information from an ever increasing and vast amount of data. This has been noted and discussed by many researchers in the community (Aizawa et al., 2001); (Jim Gemmell et al., 2004); (Jim Gemmell et al., 2006); (Tancharoen et al., 2005). They proposed different types of context data to facilitate the retrieval operation of information such as date and time, location information and people. In addition, lifelogging data is required to be accessible over many decades. Users might face the problem of opening their file as a result of software migration from one generation to the next. Gordon Bell discovered that he could not access some of his data because the format was obsolete (Bell G. 2007). Furthermore, the lifelogging community is still facing problems of security, ethical and social privacy issues, especially at the evaluation stage. Moreover, the majority of previous systems adopted only one type of data and presented no real user interface for that data. I adopted and combined the lessons learned from chapter two with the lifelogging issues and challenges found in previous lifelogging systems and literature in chapter three to design and build a novel lifelogging system in chapter five. Chapter five investigated

how human memory could react and respond to queries related to events. It was discovered that exploring lifelogging data on a timeline could support people to retrieve their past experiences and allow them to describe specific events when they reviewed and monitored all of their captured data at the same time. On the other hand, sometimes they could not distinguish, recognise or remember numerous indoor actions and activities as a result of photos being very similar or ambiguous such as blank, dark or blurry photos. In addition, logged photos occasionally did not tell the user anything about the main activity itself as a result of pointing the camera in another direction or something covered the lens. Furthermore, capturing the vast amount of photos in small places, such as at home or in the office, could confuse the users when attempting to retrieve specific moments. Moreover, the first study of face-to-face observations allowed us to monitor, find and understand the critical features of the prototype itself. For example, I tracked and followed the participants steps to monitor how they create their visual cues, including the time they spent doing this and the number of movements the users performed on the interface to achieve their target goal. Chapter six introduced the design and the architecture of the IsstLog system to capture and present vast amounts of heterogeneous data. Chapter seven investigated different strategies that people followed to create their visual cues on the IsstLog user interface. I have made contributions to the techniques used to capture and present large, diverse lifelogging data sets. In additions, I used wireless accelerometer sensors to capture users' actions and activities. I found that participants could describe different memories, such as actions, place, emotional state, physical state, intentions and thoughts when they combine multiple types of data together. Another key finding was that the log movement data of the body, hand and objects supported participants to easily locate the activities. In addition, this allowed them to segment sequences of their activities into distinct events and search the data based upon the physical activity. Moreover, combinations of heterogeneous data about an event could provide memory cues to the users to describe their events and encourage them to combine more data when they need to.

8.3 Challenges faced

A number of challenges were faced during this work. The first challenge was to address what data could be captured to trigger memory and how to present it for the users. The second challenge faced was how to present the vast amounts of captured data visually. The next challenge faced was the evaluation of the lifelogging user interface. Initially,

I designed and built the first prototype to track and monitor how easily participants could use the proposed lifelogging capture tools to collect their data and answer some basic questions such as what time they prefer to collect their data and for how long? After which I then monitored how they used the prototype interface to connect their data and to create visual cues. This investigation of the prototype and the memories retrieved allowed me to improve my understanding of what data caused the remembrance of information and this supported me in identifying clear patterns between the logged data and the memories retrieved.

The fourth challenge faced was to develop a working prototype for lifelogging, which is based on the prototype presented in chapter five, in order to improve and enhance the usefulness of the prototype. The implementation of the prototype provided numerous technical challenges as a result of the user interface's different components and the vast amount of heterogeneous data. Testing the prototype architecture and the methods of building the system led to the development of the concept of a software environment for prototyping context aware applications. The software environment reduced the technical challenges and act of the complex system building into multiple tasks through the user interface. Context data such as location information, date and time, and the movements of body, hands and objects were used to facilitate and speed up the retrieval process.

The last challenge faced was to design suitable experiments which could be used to evaluate the lifelogging user interface with respect to security, ethical and social privacy. The first IsstLog study showed that lifelogging has the potential to intrude upon participants private lives in ways they do not anticipate. The fact that multiple participants felt the need to disguise their activities during this short study, which involved a relatively small number of participants, highlights how prevalent these issues may become if lifelogging is widely adopted. It was clear that although the participants knew how to limit the collection of data, they did not anticipate when the lifelogging might need to be paused and instead had to destroy the data after its collection. This digital subterfuge was conducted by more than one participant which leads us to suggest that the necessity for such covert activities might be familiar to younger adults who have grown up in the era of social media. The outcome of the study also suggests that future lifelogging studies need to allow users to retrospectively, without consultation with researchers, have the option to not simply destroy any part of their data, but to obfuscate it in a way that the researchers themselves cannot detect.

8.4 Answers to the research questions

This section answers the research questions introduced in Section 1.6 that guided the research presented in this thesis. It discusses the implications of these answers for augmenting autobiographical memory.

What data could be used to trigger and simulate human memory?

Collection of digital data such as time, place, people, or combinations of two or more can serve as cues to trigger human memory about experience. Chapter five investigated interactive selected types of data that people can collect and use for stimulate, augmenting and supporting their memory to remember past experiences. I found that photos were the most supportive and other valuable data could be integrated to increase the powerful supportive nature of the photos and to stimulate different types of memory to remember past activities. In addition, data integration gave me a clear sign of how human memory could react and respond to queries related to any event. On the other hand rises many failure, Insufficiency, and inadequate data that encouraged me to discuss in chapter six. For example, blurry and dark photos confused their users and did not tell them anything about the main activity itself as a result of pointing the camera into another direction or something covered the lens. In addition, capturing vast amounts of photos in a small places, such as the home or offices, can confuse the users to retrieve particular moments. Thus, In chapter six the new diverse lifelogging data sets adopted to captured more data to stiumalte different types of memory. For example, accelerometers log data were useful to segments data captured at the same time into events to encorage users to find their events more easy. In addition, allow them to locate the start and the end time of each event.

What devices could be used to capture lifelogging data, how could they capture it, and for how long?

We found that capturing lifelogging data passively with a minimal user intervention is the main core of collecting lifelogging data. For example, collecting data from personal devices such as the mobile phone and computer could overlap in capturing values part of everyday activities with a little effort. In addition, other lifelogging data such as Vicon Revue, accelerometers, and electricity consumption power.

Does collected data support long-term memory?

Both the studies show that collected data could support long-term memory to remember past experience. For example, I found that in the first study participants described almost of their events when they joined review their data. In addition, they manage to extend their talk when they joined two or more types of data together to describe their events. This result confirmed in the second study when I used two observation sessions for each week. I found that, although participants used different strategies to create their memory cues, their description of many events were identical and sometime the second session includes more detail than the earlier one.

How can we determine whether such data reflects upon a users' lifestyle?

Actually answering such question of lifelogging could be obtained only when participants use the lifelogging user interface for long time during collecting their data. Which means that participants need to capture and watch their data for long period at least six months, and then observation could take place to assist and compare their behaviour and interaction to find out any changes.

Does processed data add more influence to trigger human memory?

I obtained the answer of this question from the first study when I asked the participants to answer some memory questions without using the prototype. In many cases they could not answer the questions or remember the event itself, but when they used the user interface and searched their data they described and extend their answers. In addition, in the second study participants extended their answers and added more description each time they combine and add new data.

How could we build an interactive interface to introduce that data collection in a visual manner, and how should we formulate that data so that it can simulate and trigger human memory?

One of the main aims of lifelogging systems is how to present visually lifelogging data. During the time of designing and built the first prototype user interface I attempted to present the data in visual format to allow participants to think of how to create their visual cues instead of waste their time thinking of what data is that. In addition, the first study chapter five gave me a clear understanding of how participants connect their data, what data they usually start with, and what their main goal of that. I achieved all of that

when I tracked and monitored their movements on the prototype and when they think a loud to describe their events and what they intend to do. In the second study chapter six I redesigned the prototype depending on the observations results. I attempt to make the user interface more interactive, easy, and fun by presenting different types of data visually to allow them to use and combine different types of data that able to aid them to create make values and interactive visual cues for their memory.

Does the system introduced in this thesis support, augment, and trigger people to remember their past life experience?

The results obtained from the two studies confirmed that almost of events that person engaged are stored in their long-term memory and cues are needed to trigger their memory to retrieve them. For example, the first study shows that participants could not describe their activities when they relied only on their autobiographical memory, but when they used the prototype the situation was change. In addition, the second study illustrated that participants could extend their talk when they segmented their activities into events and combine new data.

8.5 Future Work

The previous two sections summarise the main contributions of this doctoral work and the challenges faced. The ramifications of this work are notable and warrant further investigation. Many avenues that can be taken further for future research emerged in the research described above. In this section I describe some of the main opportunities for progressing the work. As I mentioned previously, this work has increased my understanding of what data needs to be captured , how data could stimulate and trigger different types of memory and how to present that data visually. However, the work has been limited to certain multiple heterogeneous data and the user interface employed the features of date and time only to locate and access this data. An extension of this work could be modifying the system to enhance and increase the productivity and usefulness of the lifelogging system. For example, physical activities recognition and machine could be used to process data logged by the accelerometers to ease searching operation. In addition, more meaningful data could be easily collected, added and employed to trigger memory to obtain further memories. For instance, Smartphone' PC suites could allow users to synchronise and upload more effective and valuable data such as their Gallery, Music, People, Calendar, Bookmarks and Documents. In addition, Facebook and Twitter could be uploaded and combined with the data. Moreover, the location

information could be captured through the network to minimize battery drain and work indoors also.

Although, IsstLog tools allows users to communicate and access almost all of their data, more functions and tools could be added to increase the power of the system and allow users to perform more interactions with the system. For example, a future system could allow users to search by using keywords or specify different types of location by using combinations such as time and location of the photos. In addition, users could designate certain photographs to be “landmarks”. This could support users in finding and accessing photos that were took close to the time the “landmark” photos was taken. Furthermore, using semantic information could help augment memories by allowing access to information items based upon the typical characteristics of the information types and the relationships between them. Moreover, text based searching to find documents could be used, similar to the current search engines Yahoo and Google. Additionally, an extension of the visual user interface of the software environment to enable other modalities of programming such as activity recognition needs investigation. Finally, various experiments which investigate the usefulness of the system in a real world setting need to be designed and run. An example scenario is in examining the system’s ability to capture data of people of different ages, for at least one year, and then investigate the usefulness of the system user interface in enhancing and augmenting memory by searching, browsing and combining data to create visual cues and remember past actions and activities.

With regards to the privacy and ethical concerns this issues should be pull out by define the objects of the study itself. I argue that existing privacy and ethical policy do not propose meaningful limits on unwanted uses of lifelogging technology and some of the privacy concerned are overblown. For example, Eagle and Pentland said that shared lifelogging data could provide information about historical studies and analysis of social patterns. Rawassizadeh stated that shared lifelogging information could have contributions in many fields, such as monitoring, recommendation, and health systems (Rawassizadeh, 2010). I believe that sharing personal lifelogging information with society would offers great benefits for both users and society at large. For example, it could be used to watch social changes, such as the way people speak, dress, or style their hair.

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Appendix A



APPLICATION FOR APPROVAL OF A RESEARCH PROGRAMME INVOLVING HUMAN PARTICIPANTS AND NOT SUBJECT TO CLINICAL ETHICS PROCEDURES (NRES)

KHIS Project No. (if the project is for external funding)

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Please consult with your faculty Grants and Contracts Officer

This application form is to be used by **STAFF** and **STUDENTS** seeking ethical approval for an individual research project or programme involving the study of human subjects in a non-clinical setting. Where the study involves a clinical setting or material derived from a clinical setting (e.g. tissue, blood or other bodily fluids, patient records, intervention procedures etc.) ethical approval or advice must be sought through the systems operated by the National Research Ethics Service – see <http://www.nres.npsa.nhs.uk>.

A completed version of this document should be emailed to the Secretary of your appropriate Ethics Committee in the University. *Applications must be completed on this form; attachments will not be accepted other than those requested on this form. This form has been designed to be completed electronically; no handwritten applications will be accepted.*

Research must **NOT** begin until approval has been received from the appropriate Ethics Committee.

CATEGORY: ☒ UNDERGRADUATE research ☐ POSTGRADUATE research ☐ STAFF research

PROGRAMME/PROJECT TITLE: Lifelogging embedded sensors for creating memory cues

NAME OF RESEARCHER(S): Esmail Mohamed

NAME OF SUPERVISOR(S): Prof. Patrick Olivier

DATE: 17/03/2011

DECLARATION BY RESEARCHERS

The information contained in this application is accurate. I have attempted to identify all risks that may arise in conducting this research and acknowledge my obligations and the rights of the participants.

Researcher(s) Name: Esmail Mohamed Date: 17/03/2011

Supervisor Name: Prof. Patrick Olivier Date: 17/03/2011

(Office Use Only)

The appropriate Ethics Committee has considered the ethical aspects of this proposal. The committee recommends that the programme/project be:

☒ approved ☐ deferred ☐ not approved

PART A

1. YOUR CONTACT DETAILS

Please provide contact details for all researchers named on this application:

NAME	EMAIL	PHONE
Esmail Mohamed	e.s.t.Mohamed@ncl.ac.uk	07775847098

2. TYPE OF PROGRAMME/PROJECT

Please mark **ONE** box to indicate the predominant nature of this program/project.

- a) Questionnaire/Survey ☐
e.g., surveys of members of particular groups/organizations, mail out questionnaires, street surveys
- b) Experiment ☐
e.g., participants completing tasks under controlled conditions, use of tasks/methods other than or in addition to questionnaires/surveys.
- c) Observational ☒
e.g., observing people behave in a natural setting or in a laboratory
- d) Other ☐
Please describe:

3. PARTICIPANTS

		YES	NO	N/A
a)	Will you inform participants that their participation is voluntary?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b)	Will you inform participants that they may withdraw from the research at any time and for any reason?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c)	Will you inform participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d)	Will you obtain written consent for participation?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e)	Will you debrief participants at the end of their participation (i.e., give them an explanation of the study and its aims and hypotheses)?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f)	Will you provide participants with written debriefing (i.e., a sheet that they can keep that shows your contact details and explanations of the study)?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- | | | | | |
|----|--|-------------------------------------|--------------------------|--------------------------|
| g) | If using a questionnaire, will you give participants the option of omitting questions they do not want to answer? | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| h) | If an experiment, will you describe the main experimental procedures to participants in advance, so that they are informed about what to expect? | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| i) | If the research is observational, will you ask participants for their consent to being observed? | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

If any answers are YES, please supply copies of any documents in support of your answers – e.g. information sheets, drafts of questionnaires, etc.

IMPORTANT If you have marked **NO** to any of the questions above and have marked **BOX A** below, please give an explanation (no more than 300 words):

4. INSURANCE

Please consult with the appropriate officer in the University Finance Office concerning insurance cover for the research or indemnity.

- (a) What arrangements will be made for insurance and/or indemnity to meet potential legal liability of the University or other external funder for harm to participants arising from the management of the research?

Standard University insurance arrangements subject to approval by ethics committee.

- (b) What arrangements will be made for insurance and/or indemnity to meet the potential legal liability of the University or other external funder for harm to participants arising from the design of the research?

Standard University insurance arrangements subject to approval by ethics committee.

- (c) What arrangements will be made for insurance and/or indemnity to meet the potential legal liability of investigators/collaborators and, where applicable, Site Management Organizations, arising from harm to participants in the conduct of the research?

Standard University insurance arrangements subject to approval by ethics committee.

Please attach appropriate documents


5. ETHICAL ISSUES

	YES	NO
a) Will this programme/project involve deliberately misleading participants in any way?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) Is there any realistic risk of any participant experiencing any degree of physical or psychological harm, distress or discomfort?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c) Will you be administering drugs or other substances to your participants, or taking fluid or other samples from them?	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) Will your participants fall into any of the following special groups?		
Schoolchildren (under 18 years of age)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
People with learning or communication disabilities	<input type="checkbox"/>	<input checked="" type="checkbox"/>
People in custody	<input type="checkbox"/>	<input checked="" type="checkbox"/>
People engaged in illegal activities (e.g., drug-taking)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Other vulnerable people	<input type="checkbox"/>	<input checked="" type="checkbox"/>


IMPORTANT If you have marked **YES** to any of the questions above, then you must mark **BOX B** below and complete **PART B** of this form.

6. ETHICAL ASSESSMENT

Please mark **ONE** box:

A I consider that this programme/project has **NO** significant ethical implications to be brought before an Ethics Committee. 

PROGRAMME/PROJECT SUMMARY. Please provide a brief description of your programme/project. This should be sufficient for reviewers of this application to ascertain exactly what your research involves. For instance, it should include information about the aims of the programme/project, and also the sources of your participants (i.e., target group/s) and how you will be recruiting them. Also include a brief summary of what participants will be required to do (e.g., main procedures, tasks, tests). This description must be in simple, everyday language that is free from unnecessary technical terms and no more than 300 words. Please also attach a copy of your consent form. Also attach a copy of any questionnaires (if using them in this research). You do not need to complete Part B of this form.

B I consider that this programme/project **MAY** have ethical implications that should be brought before the Ethics Committee, and/or it will be carried out with children or other vulnerable populations. 

If you have marked this box, you **must** complete **PART B** of this form.

PART B

You need only complete this part if you believe that your programme/project may have ethical implications (e.g., use of deception) and you have marked **BOX B** above, or your programme/project will be carried out with children or other vulnerable populations.

1. PROGRAMME DETAILS

1.1 PROPOSED DURATION OF PROGRAMME

From: 17/03/2011

To: 05/07/2011

1.2 PROGRAMME/PROJECT OUTLINE AND AIMS: *Briefly describe the aims of this research as well as the main tasks (or tests) that participants will be required to complete. This description must be in everyday language, free from jargon, technical terms or discipline-specific phrases (No more than 300 words).*

The main aim of the study is to evaluate an interactive system that records and allows retrieval of everyday life experience in a multimedia format.

Other aims include:

1. *Design and trial of the software.*
2. *Evaluate the applicability of the designed software by logging data from everyday activities and monitoring participants behaviour and interaction with that data to understand how they use their data as memory cues.*
3. *Produce recommendations and suggestions to improve lifelogging systems.*

The participants are required to complete following tasks:

1. To use digital lifelogging devices to capture various data from their everyday environment for three continuous periods of five days.
2. After approximately one month they will be invited to attend a one-to-one interview in which they use two different prototypes. During the usage session they will be expected to display all of their collected data visually, and use the interfaces to answer some open ended question related to their data. Through this task we will monitor their use their data to support memory retrieval tasks.
3. At the end of the interview we will ask them their feedback about simplicity, usability, and advantage and disadvantage of each prototype. Furthermore, any other tools and functions that they expect to find and they did not.

1.3 PROPOSED METHOD: *Provide an outline of the proposed method, including where and how data will be collected, and all tasks that participants will be asked to complete. Present this outline of the method in a step-by-step chronological order, and avoid using jargon and technical terms as much as possible (No more than 700 words).*

The study has two main stages: (a) collection of lifelogging data in everyday life; (b) interview and observation of use of lifelogging retrieval interface. At capture stage, participants will asked to collect various data for continuous periods of five days by using: digital camera (a SenseCam) to capture photos every 10 seconds passively without their intervention; Nokia cell phone to capture GPS location information; 8 accelerometers placed in key locations in their home environments and electricity consumption sensors. In addition, two software programmes will be installed on their personal computers: (a) to make screen captures of their computer screen every five seconds when they strike their computer keyboard or when they move their mouse pointer; (b) to archive all sent, opened and read emails. They will be asked to connect an electricity consumption meter to an everyday electrical device, such as TV, Kettle or coffee maker, and toaster or microwave; and to fasten two accelerometers to their body (on the wrist and on the waist), other on some of their everyday objects such as: front door, back door, kitchen door, fridge, wash machine, and sitting room window curtain.

Second stage will take place on average of four week after collecting data. We will interview participants individually to attend one-to-one interview for at least 90 minutes at Culture lab, Newcastle University or at their homes depending on their desired. We will inform them that the interview will be recorded by using video camera and their data it will be safe and secure. During the interview they will use two lifelogging interface software to display all of their collected data visually, and we will ask them some open ended question related to their data, we will ask them about emotion, actions, and events. Our task in this interview is to monitor and understand how they use their data to support their memory? and how they link that data together to create values cues that able not only to make them remember past information, but to relive that events as well. In addition, by comparing their interaction in both prototypes we can understand what data and other factors could impact their remembrance.

At the end of the interview we will ask them their feedback about simplicity, usability, and advantage and disadvantage of each prototype. Furthermore, any other tools and functions that they expect to find and they did not.

1.4 DOES THIS PROGRAMME/PROJECT REQUIRE APPROVAL FROM AN EXTERNAL ETHICS COMMITTEE?



YES



NO

IF YES, HAS APPROVAL ALREADY BEEN GRANTED?



YES

(please attach a copy of the approval letter)



NO

(please submit a copy of the approval letter as soon as it becomes available. Note that you cannot proceed with data collection until approval has been granted by all relevant ethics committees)

2. PARTICIPANT DETAILS

2.1 NUMBER OF PARTICIPANTS REQUIRED: Ten participants

AGE RANGE OF PARTICIPANTS: Over 25 years old

2.2 DOES THE RESEARCH SPECIFICALLY TARGET: (Select as many as applicable)

	YES	NO
a) students or staff of this university	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b) adults (over the age of 18 years and competent to give consent)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c) children/legal minors (anyone under the age of 18 years)	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d) the elderly	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e) people from non-English speaking backgrounds	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f) pensioners or welfare recipients	<input type="checkbox"/>	<input checked="" type="checkbox"/>
g) anyone who is intellectually or mentally impaired to the extent that they cannot provide consent	<input type="checkbox"/>	<input checked="" type="checkbox"/>
h) anyone who has a physical disability	<input type="checkbox"/>	<input checked="" type="checkbox"/>
i) patients or clients of professionals	<input type="checkbox"/>	<input checked="" type="checkbox"/>
j) anyone who is a prisoner or parolee	<input type="checkbox"/>	<input checked="" type="checkbox"/>
k) any other person whose capacity to consent may be compromised	<input type="checkbox"/>	<input checked="" type="checkbox"/>
l) any groups where a leader or council of elders may need to give consent on behalf of the participant	<input type="checkbox"/>	<input checked="" type="checkbox"/>

2.3 SOURCE AND MEANS BY WHICH PARTICIPANTS ARE TO BE RECRUITED

Please provide specific details as to how you will be recruiting participants. Where will your participants be sourced? How will people be told you are doing this research? How will they be approached and asked if they are willing to participate? If you are mailing or phoning people, please explain how you have their names and contact details. Also mention any specific criteria for choosing participants (i.e., exclusion/inclusion criteria) and whether you will provide incentives for participation (e.g., payment). If a recruitment advertisement is to be used for this programme/project, please attach a copy to this application.

Participants will be selected from different groups of ages. None of participants had prior experience of lifelogging: wearing SenseCam or using GPS units. We will invite them either through personal connections, by email and might be use society centres, student's communities to get some volunteers. All participants will take part in the user study individually; we will ask them to perform the study tasks as described in the procedure section. Financial incentives will be provided for the participants. Their contact details will be stored in a password protected computer and used only for the purpose of the research.

3. MANAGEMENT OF ETHICAL ISSUES

3.1 POTENTIAL RISK TO PARTICIPANTS AND RISK MANAGEMENT PROCEDURES

Identify, as far as possible, all potential risks (small and large) to participants (e.g. physical, psychological, social, legal or economic, etc.) that are associated with the proposed research. Also explain any risk management procedures that will be put in place.

To protect the participants' confidentiality the researcher will make sure that all the participants understand their role in the study and agree to being observed and video/audio recorded (through signing a consent form). The researcher will anonymize the data (through data and image modification) and keep it in secure storage (password protected and encrypted) to protect the participants' confidentiality. The study will be conducted in Newcastle University. The research will be conducted in daytime therefore no risk collecting the data out of working hours is anticipated at this stage.

3.2 DEBRIEFING

It is a researcher's obligation to ensure that all participants are fully informed of the aims and methodology of the programme/project, and to ensure that participants do not experience any level of distress, discomfort, or unease following a research session. Please describe the debriefing that participants will receive following the study and the exact point at which they will receive the debriefing. Also describe any particular provisions or debriefing procedures that will be in place to ensure that participants feel respected and appreciated after they leave the study. Please attach a copy of the written debriefing sheet that you will give to participants. If you do not plan to provide a written debriefing sheet, please explain why.

All the participants are provided with the participant information sheet prior to the study and this includes information about the aims and methodology of the project. Invitation letters are sent just before each stage of the study to make sure that the participants know what to expect on the day.

4. INFORMED CONSENT

4.1 PLEASE DESCRIBE THE ARRANGEMENTS YOU ARE MAKING TO INFORM PARTICIPANTS, BEFORE PROVIDING CONSENT, OF WHAT IS INVOLVED IN PARTICIPATING IN YOUR STUDY? *If you will be providing participants with a written information sheet, please attach it to this application.*

The participants will be provided with the written information sheet (please see attached)

4.2 PLEASE DESCRIBE THE ARRANGEMENTS YOU ARE MAKING FOR PARTICIPANTS TO PROVIDE THEIR FULL CONSENT BEFORE DATA COLLECTION BEGINS? *Participants should be able to provide written consent. Please attach the consent form that you will be using in your programme/project. If you think that gaining consent in this way is inappropriate for your programme/project, then please explain how consent will be obtained and recorded.*

Consent forms attached.

You have now completed this form. Please email or send this form to the Secretary of your Ethics Committee.

Participant NO: ()

Participant Consent Form

The title of the study: *Lifelogging embedded sensors for create memory cues*

by Prof. Patrick Olivier, Newcastle University.

Name of Participant: _____

I agree to take part in this study. This agreement is of my own free will.
I have had the opportunity to ask any questions about the study and I realise that I may withdraw from the study at any time without giving a reason.

I have been given full information regarding the aims of the research and have been given information with the Researcher's names on and a contact number and address if I require further information. All personal information provided by myself will remain confidential and no information that identifies me will be made publically available

I agree to my video recorded and audio recorded interviews to be stored in a password protected file and used as a data source in this study.

I am free to ask any questions at any time before and during the study. I have been provided with a copy of this form and the participant information sheet.

I understand that I will perform two tasks in this study:

1. I will use some digital devices to log five continues days of my life experience.
2. I will use two software interfaces to monitor and search my logged data. My experience of using the software will be recorded and share my views on the software with the researcher.

Name of participant (print)..... Signed.....

Date: ---/---/2011

Name of researcher (print)..... Signed.....

Date: ---/---/2011

Researcher's contact details: Esmail Mohamed, Culture Lab, School of Computing Science, University of Newcastle upon Tyne, NE1 7RU

e.s.t.Mohamed@ncl.ac.uk

Tel: 07775847098

Project supervisor: Prof. Patrick Olivier

Email: p.l.Oliver@ncl.ac.uk

Participant NO: ()

Participant Consent Form two**‘Showing videos interview of using the first and second prototypes’**

The title of the study: *Lifelogging embedded sensors for create memory cues*’ by Prof. Patrick Olivier, Newcastle University.

Name of Participant: -----

I agree to my interview video recorded using the first and the second lifelogging interface to be shown and discussed in one-to-one and focus group interviews. I understand that the purpose of this study is to obtain feedback on using lifelogging technology to assist people retrieve their past life experience.

This agreement is of my own free will. I have had the opportunity to ask any questions about the study and I realise that I may withdraw from the study at any time without giving a reason.

I have been given full information regarding the aims of the research and have been given information with the Researcher’s names on and a contact number and address if I require further information. All personal information provided by myself will remain confidential and no information that identifies me will be made publically available.

I am free to ask any questions at any time before and during the study. I have been provided with a copy of this form and the participant information sheet.

Name of participant (print)..... Signed.....

Date: ---/---/2011

Name of researcher (print)..... Signed.....

Date: ---/---/2011

Researcher’s contact details: Esmail Mohamed, Culture Lab, School of Computing Science, University of Newcastle upon Tyne, NE1 7RU

e.s.t.Mohamed@ncl.ac.uk

Tel: 07775847098

Project supervisor: Prof. Patrick Olivier

Email: p.l.Oliver@ncl.ac.uk

Participant NO: ()

Participant Consent Form Three

**Showing videos of your recorded lifelogging interview
at conferences and public presentations**

The title of the study: *Lifelogging embedded sensors for create memory cues* ' by Prof. Patrick Olivier, Newcastle University.

Name of Participant: -----

I agree to my interview video recorded of using the first and the second lifelogging interface to be shown at conferences and public presentations. I understand that my identity may be revealed and I agree to do that.

This agreement is of my own free will. I have had the opportunity to ask any questions about the study and I realise that I may withdraw from the study at any time without giving a reason.

I have been given full information regarding the aims of the research and have been given information with the Researcher's names on and a contact number and address if I require further information. All personal information provided by myself will remain confidential and no information that identifies me will be made publically available.

I am free to ask any questions at any time before and during the study. I have been provided with a copy of this form and the participant information sheet.

Name of participant (print)..... Signed.....

Date: ---/---/2011

Name of researcher (print)..... Signed.....

Date: ---/---/2011

Researcher's contact details: Esmail Mohamed, Culture Lab, School of Computing Science, University of Newcastle upon Tyne, NE1 7RU

e.s.t.Mohamed@ncl.ac.uk

Tel: 07775847098

Project supervisor: Prof. Patrick Olivier

Email: p.l.Oliver@ncl.ac.uk

Participant NO: ()

Participant Information Sheet

Title of Study: *Lifelogging embedded sensors for create memory cues*

You are being invited to participate in a research study. Before you decide, you need to understand why the research is being done and what it would involve for you.

Please take time to read the following information carefully. If there is anything that is not clear or you would like further information, please contact us using the details provided below. Take time to decide whether or not you wish to take part.

What is the purpose of the study?

The purpose of this research is to investigate how people could use visual lifelogging data to support their memory to remember and retrieve their past actions and events. We designed and built software which allows people to display and search different types of data visually to support them to create values cues that could support their memory and to assist them to travel back in time to retrieve their past experience.

This study aims to set a paradigm of understanding of what advantages and barriers of the impact of using different types of data to support past retrieval.

What is required of me?

You are being asked to use lifelogging proposed devices to capture some of your everyday data and some data from your environment for continues five days as follow:

- 1) Using digital camera to capture photos automatically every 10 seconds.
- 2) Using mobile phone to capture GPS location information data.
- 3) Accelerometer device will be fixed into some of your everyday object to log their movement.
- 4) Two software programs will be install to you computer:
 - First software to capture your computer screen every five seconds.
 - Second software to archive sent and received emails “you can manually control this process”.

After approximately one month of capturing your data we will invite you again for short one-to-one interview to use lifelogging software and ask you for feedback of using the tools and using the software. The interview will be recorded and it will take at least 90 minutes interspersed with periods of rest.

You may be asked for permission to allowing the researcher to use your data in this way. The researcher will discuss this with you first and if you agree he will ask you to give him your written permission.

Risks to participants

There is no risk anticipated for you while taking part in this study. The information gained will NOT be used for any other purpose than the study and individual Trusts or persons will not be named. The researcher Esmail Mohamed will ask your permission to use pictures and videos of your video recorded interview at public presentations and conferences and will do so ONLY if you give him written permission for that.

Will my participation in the study be confidential?

Yes, all information provided by you will be kept strictly confidential and only used by the research team. When the information gained from all the participants is presented in project reports or publications any identifiers will be removed to ensure you remain anonymous. Videos will only be stored in password protected computer systems.

What if I change my mind about taking part?

This study is conducted in accordance with Newcastle University Ethics Policy and Code of Good Practice in Research which ensure your rights to leave this study at any time without any explanation or obligation.

What happens after I have taken part?

You can send a contact email to the researcher Esmail Mohamed so that we can send you a summary of the findings when the information is analysed and a report produced. You can request this even if you do not wish to take part in the study. To do this, please email e.s.t.Mohamed@ncl.ac.uk and request to receive the summary findings in August 2011.

What if there is a problem?

If you would like to provide feedback or have a concern about any aspect of this study, please speak to Esmail Mohamed or Prof. Patrick Olivier at School of Education, Communication and Language Sciences, University of Newcastle upon Tyne. Remember you may withdraw from this study at any time.

Contact details

If you would like further information about this research, please contact:

Name of participant (print)..... Signed.....

Date: ---/---/2011

Name of researcher (print)..... Signed.....

Date: ---/---/2011

Researcher's contact details: Esmail Mohamed, Culture Lab, School of Computing Science, University of Newcastle upon Tyne, NE1 7RU

e.s.t.Mohamed@ncl.ac.uk

Tel: 07775847098

Project supervisor: Prof. Patrick Olivier

Email: p.l.Oliver@ncl.ac.uk

Thank you for taking your time reading this!

Appendix B

Second Lifelogging prototype plan and design

This prototype aims to:

- Present new simple way to explore lifelogging data visually and interactively.
- Make presented data more powerful to trigger their users' memory.
- Display activities easy and fast.
- Simple and funny to use.

This prototype attempts to link and present visually different types of data collected by different devices such as:

- Nokia Phone to collect (Incoming calls, Outgoing calls, Missing calls, SMS sent and received, and GPS information location).
- SenseCam camera to collect (digital Photos);
- 3-D accelerometer sensor.
- Power consumption devices to collected data at home or office. Two devices will be uses to tracker electric devices).

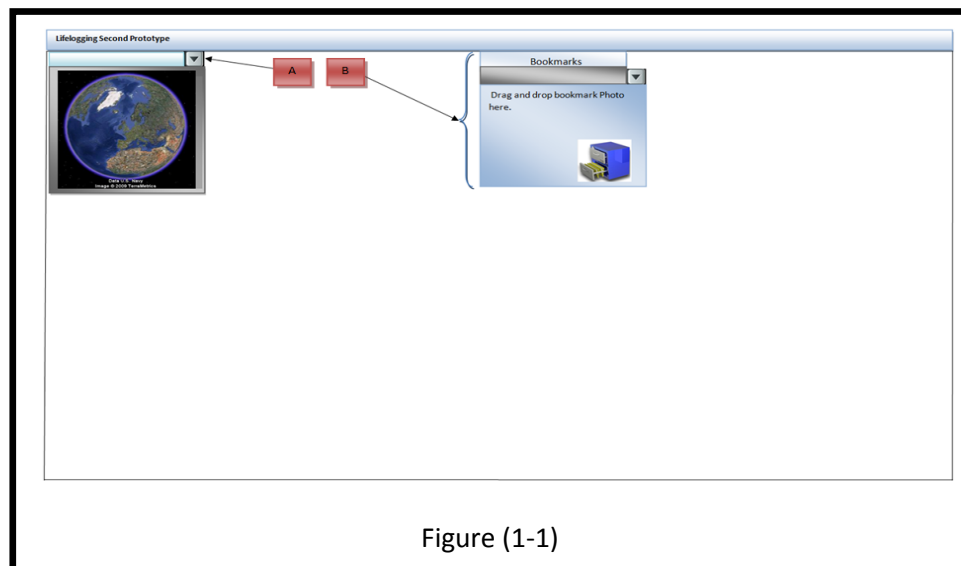


Figure (1-1)

- Received and sent emails with the complete details.
- Blog the computer activities by capture computer's screen every ten seconds.
- In general the prototype will contain two main parts **A** and **B**. The first one uses to sort, index, and retrieve data visually.

- The other one uses to store new bookmarks and to display the stored Bookmarks. See figure (1-1). At the beginning I will explain the rational and the plane design of the first part, and then I will move to the second part and do the same.

First Part, retrieve and display activities and actions:

- Users can use first part to retrieve and display visually their activities by selecting date (Year, Month, and day) of that events form the calendar which is exist on the top left corner of the prototype see figure (1-2) 1. Dates which include activities will be in bold to save users time and void them of select date does not contain any activity. For the two parts of the prototype Google earth will be used to present activities location (see figure (1-2) 2).

- Selecting date will generate and display two panes as shown in figure (1-2). One of them will be on the bottom of the prototype 3 and the other will be in the top right corner of the prototype 4. The former will be use to sort and display all actions and activities of one day at once. To do that, I divided the bottom pane into 24 parts, each of them present one hour of the day. This notion could help users to watch the whole day of activities at one time. The later contains two icons phone icon and email icon to display all of selected day phone calls and emails activities which happened during 24 hour at one time.

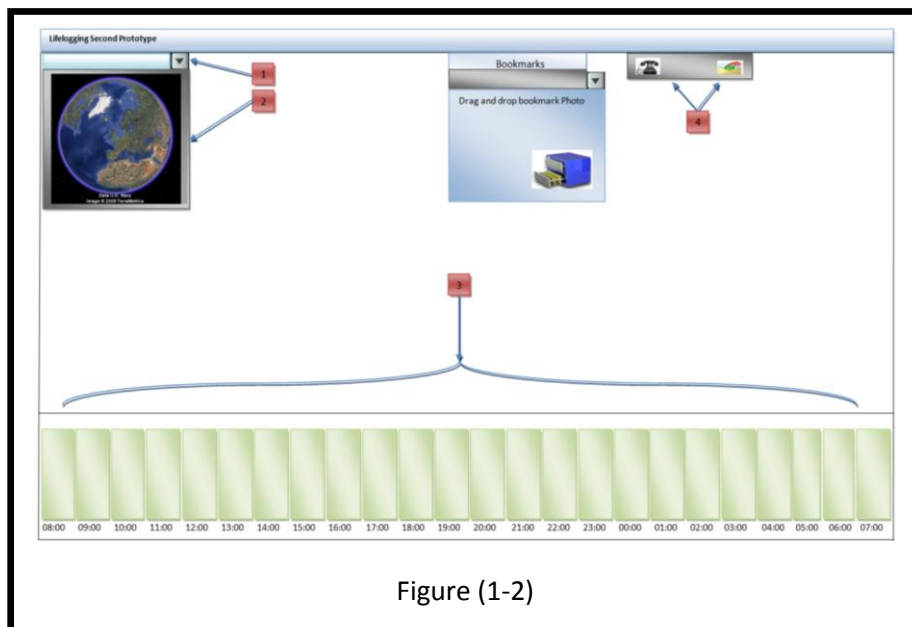





















Figure (1-2)

All emails sent or received during that selected date will be available with details such as (email subject, from, to, recipients, email body, attachments, and sub messages). The same things could be happened with the phone icon which uses to display phone history

(Incoming calls, Outgoing calls, Missing calls, and sent and received SMS). I used these two icons to collect and display different data in one place, phone calls and email could be received or sent on different times of day. For that reason to save the user's time I have chosen to put them in one place to enable users to check all phone calls and emails which are happened during the whole day at once.

To void users of open hours does not contain any activity I will display each hour activities graphically by using vertical lines with different colour each line represent one type of data. This could assist users not only to remember their live experience, but to make a complete picture of how they spent their time, that could reflect upon their life future as a whole. For instance, as shown in figure (1-3) I used:

-  To represent graphically SenseCam Photos. 
-  To represent Screen Capture Images. 
-  To represent received emails. 
-  To represent sent emails. 
-  To represent missing calls. 
-  To represent outgoing calls 
-  To represent ingoing calls 
-  To represent received SMS 
-  To represent sent SMS 

As shown in figure (1-3) hours will be appear in two different colour, to distiguish between indoor and outdoor activities. When mouse hover on specific Hour rectangle, it will be zoom in and divide into four rectangle, each rectangle will include SenseCam photo. See Figure (1-4) . So I believe that, the four selected photos could assist their users to remember one or more event that happened at selected time. From the first experiment I found that the most interesting passive capture photos are the first and the last one. I understand the main reason behind that is users could remember not only the moment of starting capture of that photos, but the reason, location, and sometimes

conversation that they had as well as their emotion. In addition, last images contents could hold answer for the reason of why they stop or pause their camera of capturing images.

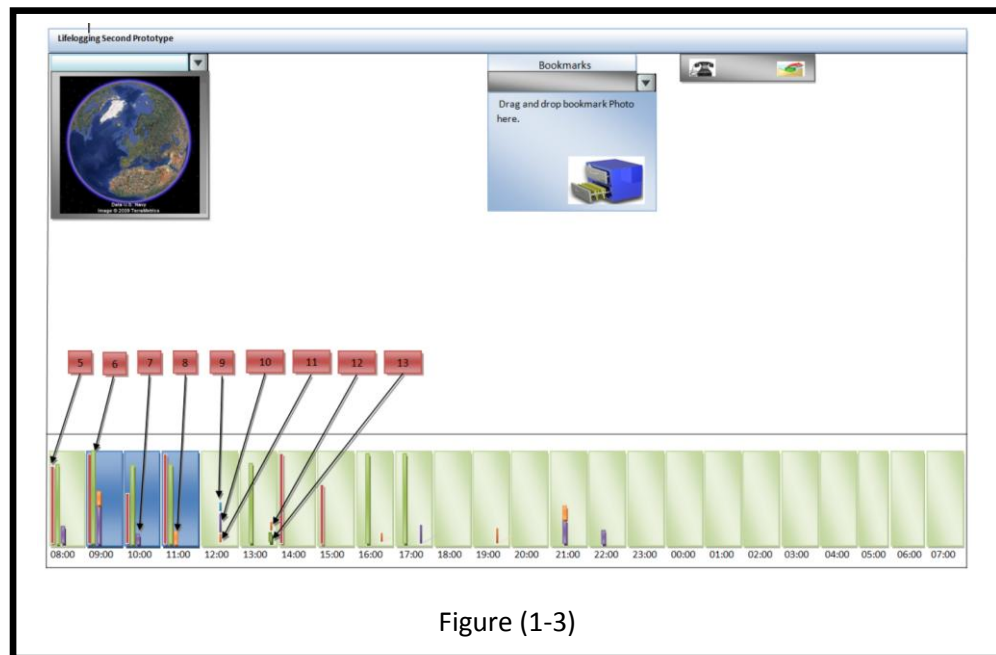


Figure (1-3)

For that reasons I adopted the first and last photos to be in the first and fourth rectangle respectively. Each photo could be zooming in to fill hour rectangle.

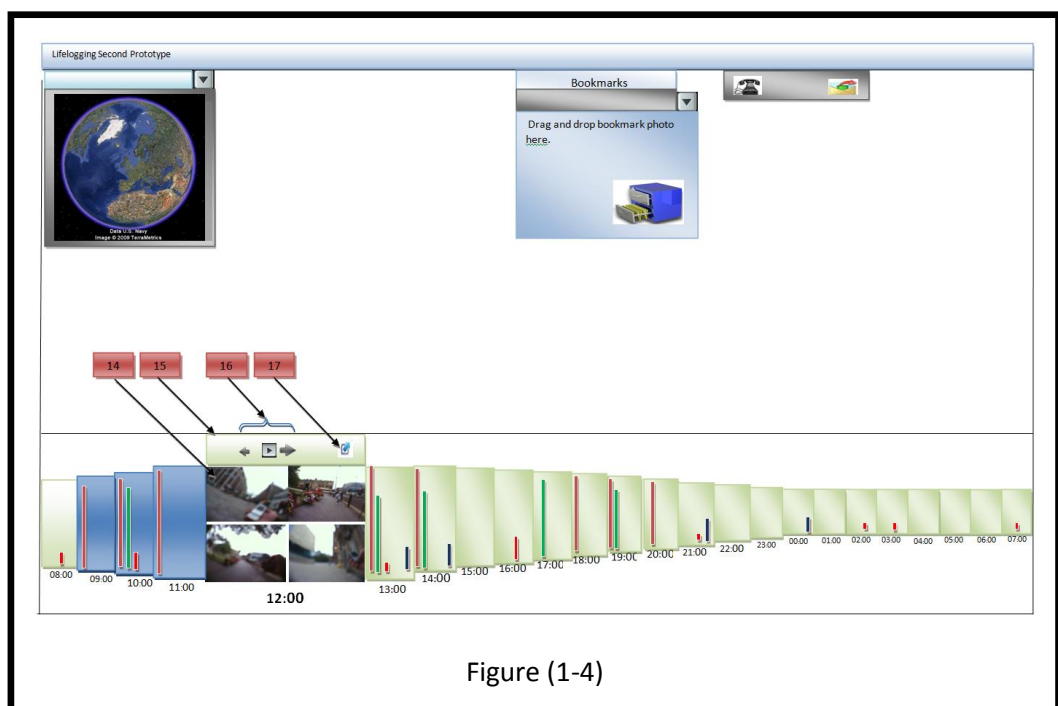


Figure (1-4)

In addition, photos control will be appear on the top of zooming hour to control all activities captured at that time 15 . This control will include functions that could be used with that hour activities and photos such as moving forward, backward, replay and pause photos as movie 16

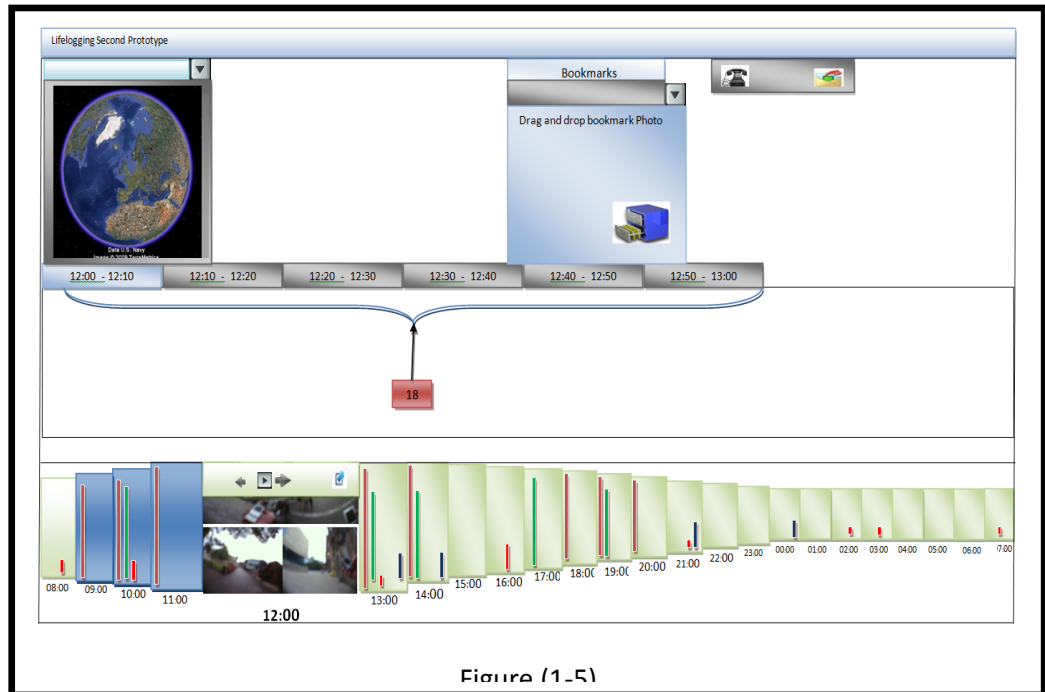


Figure (1-5)

Furthermore, display activities details of that hour. When user press detail button shown in figure (1-4) 17 new pane will be appear and selected hour will be divided into six intervals each interval will include ten minutes of activities as shown in figure (1-5) 18 .

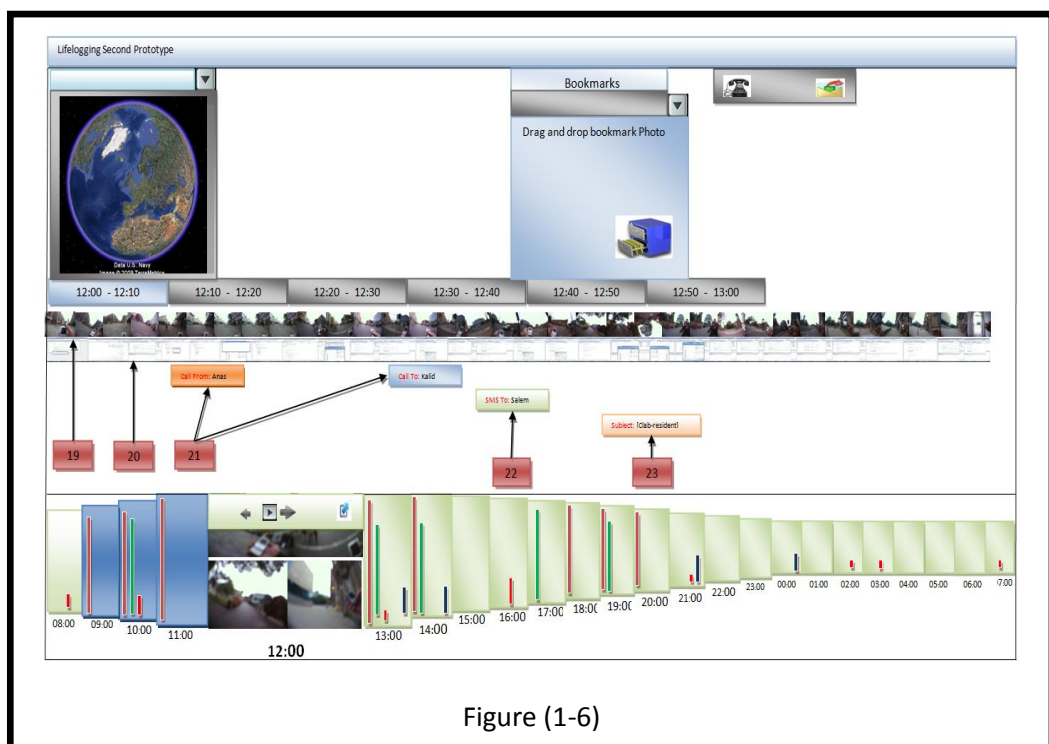


Figure (1-6)

As show in figure (1-6) each activity will appear in specific row of time line. For instance, first row will include a serial thumbnail of SenseCam photos, each photo will be positioned on its capture time **19**. Second row also will be for computer activities which it will be a serial of thumbnail capture screen images **20**. Third line will be for phone calls (Incoming, outgoing, and missing calls) **21**. Fourth line will be for received and sent SMS **22**. Fifth line, it will be for opened and sent emails **23**. After loading the entire data, time indicator **24** will be start moving from the left to the right as shown in figure (1-7), when time of the indicator equal to an event data, that data will be zoom in. Each activity will has special area to zoom in. For instance **25** will be dynamic place to display SenseCam photos. **26** To display capture screen Images. **27** It will be used to display received and sent emails. **28** Will be use to display details of (incoming, outgoing, and missing calls) and also (received and sent SMS). During indicator moving location of any activity captured outdoor will by appear on Google earth.

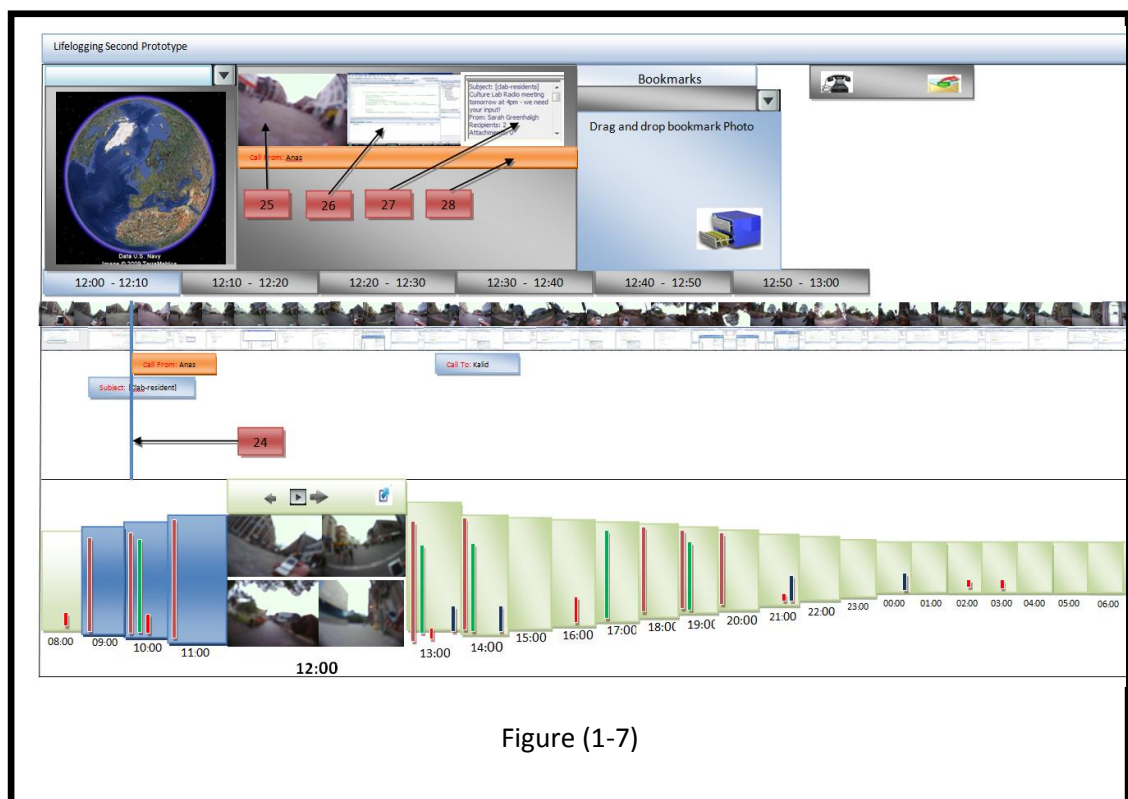
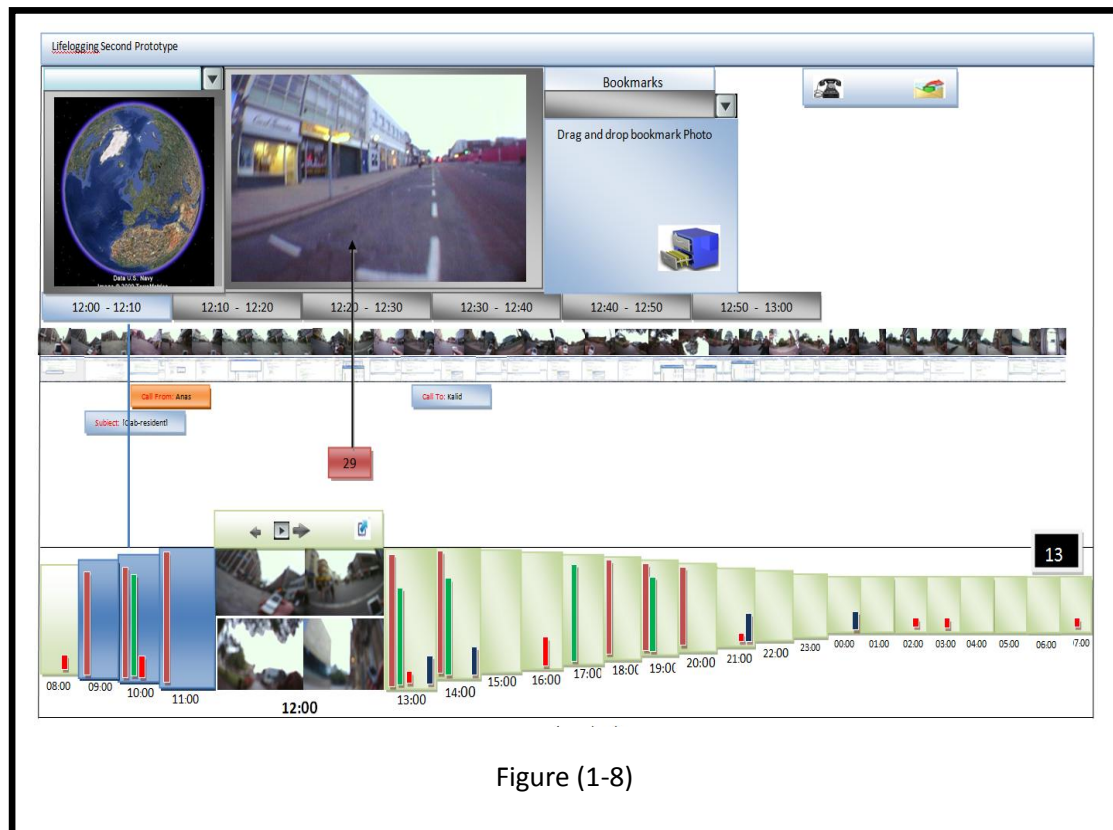
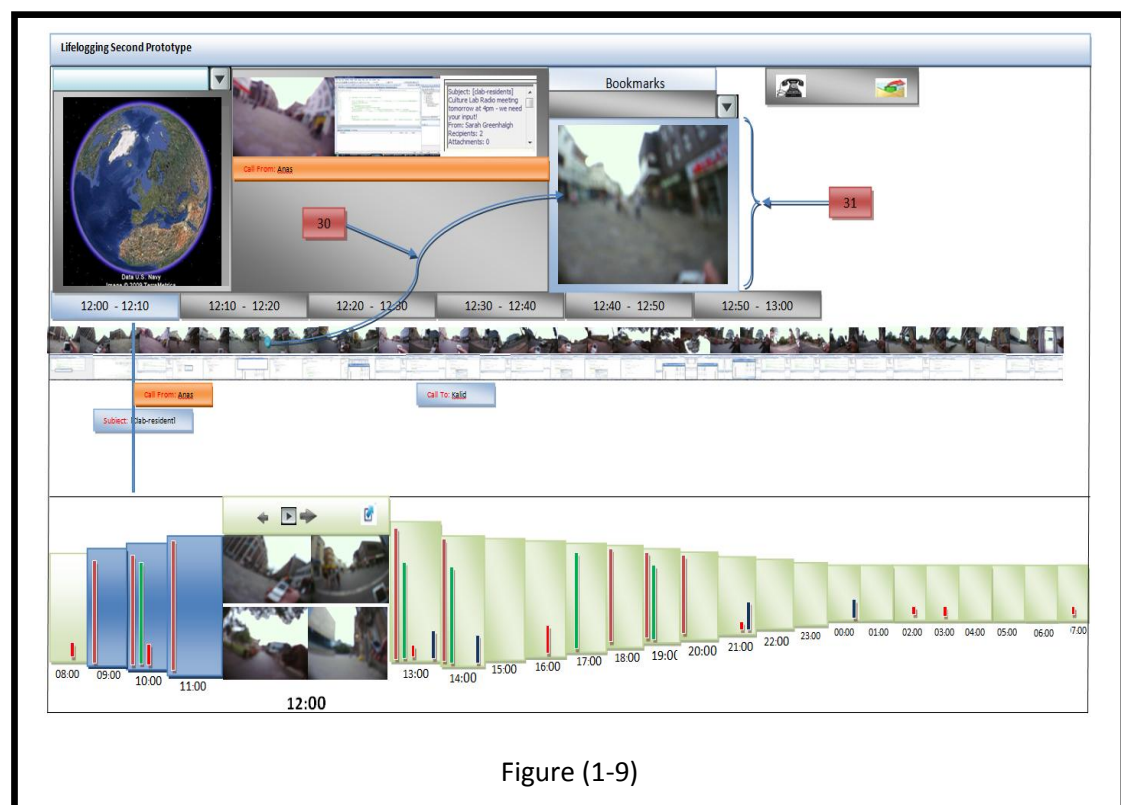


Figure (1-7)

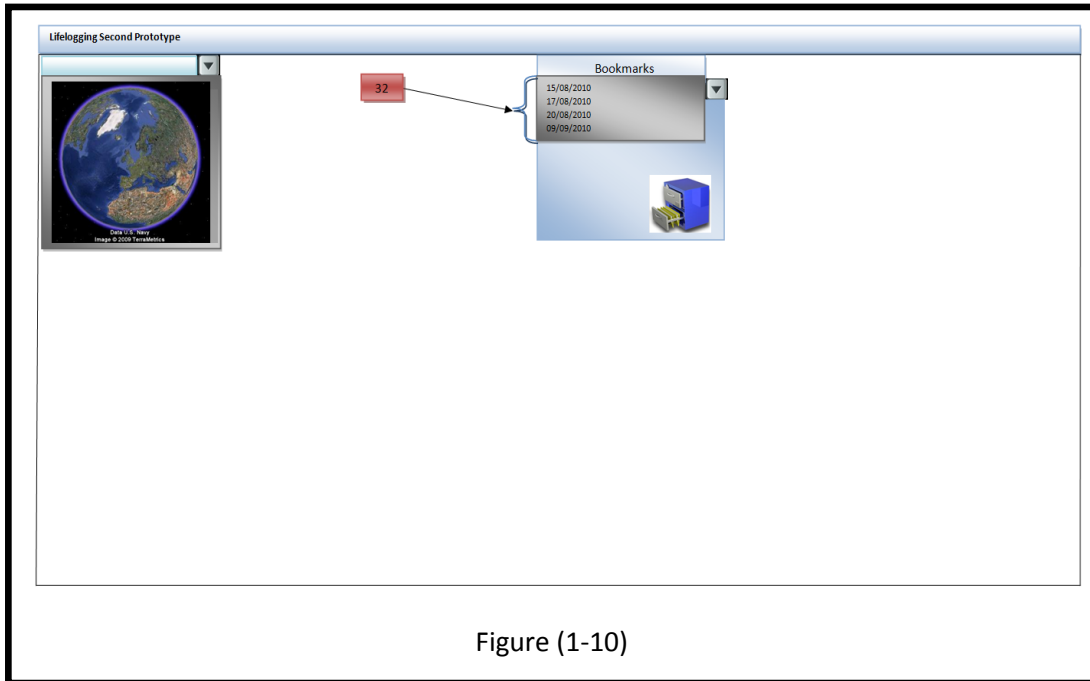
In addition, user can navigate between their SenseCam Photos and capture screen by locating their mouse on that thumbnail. That action will zoom in that thumbnail as shown in figure (1-8) **29**.



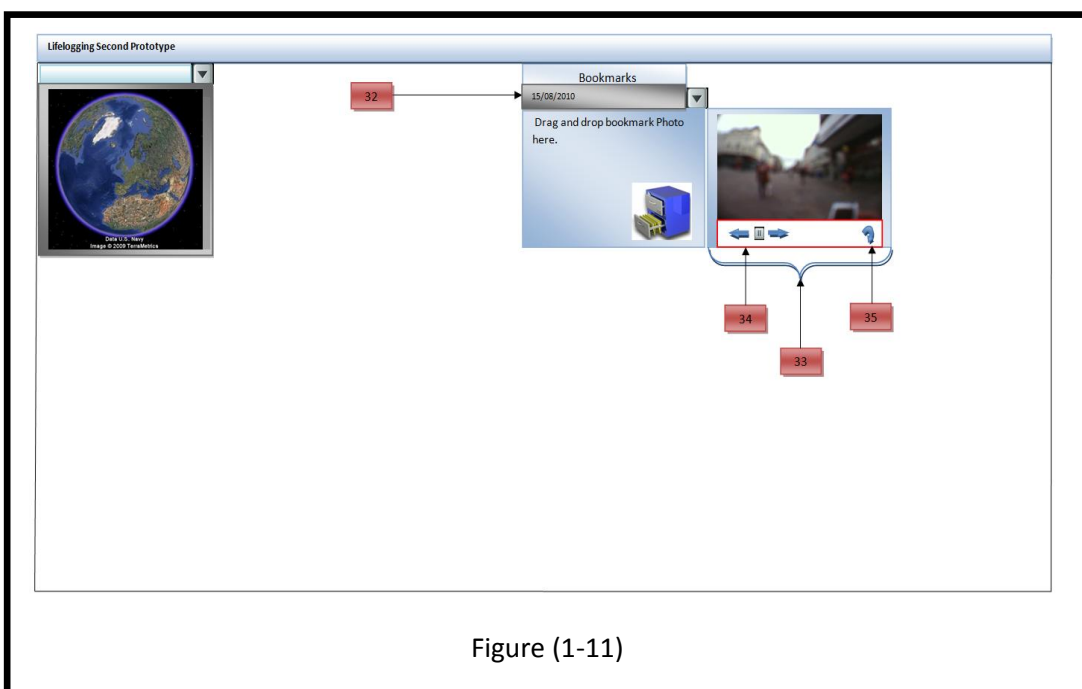
Second Part of the prototype: Users can drag and drop any SenseCam Photos into bookmark pane see figure (1-9) 31



Second part of the prototype allows users also to travel back and relive only moments that they selected from their vast amount of data. Selected photos dates will be display in a list as show in figure (1-10) 31 .



After selecting date, new window will be appearing . This window will display first photo of selected date. In the bottom of that window is 33 the control buttons which will enable the uses to display their photos as movie; also allow them to navigate forward and backward on their photos 34 35 respectively.



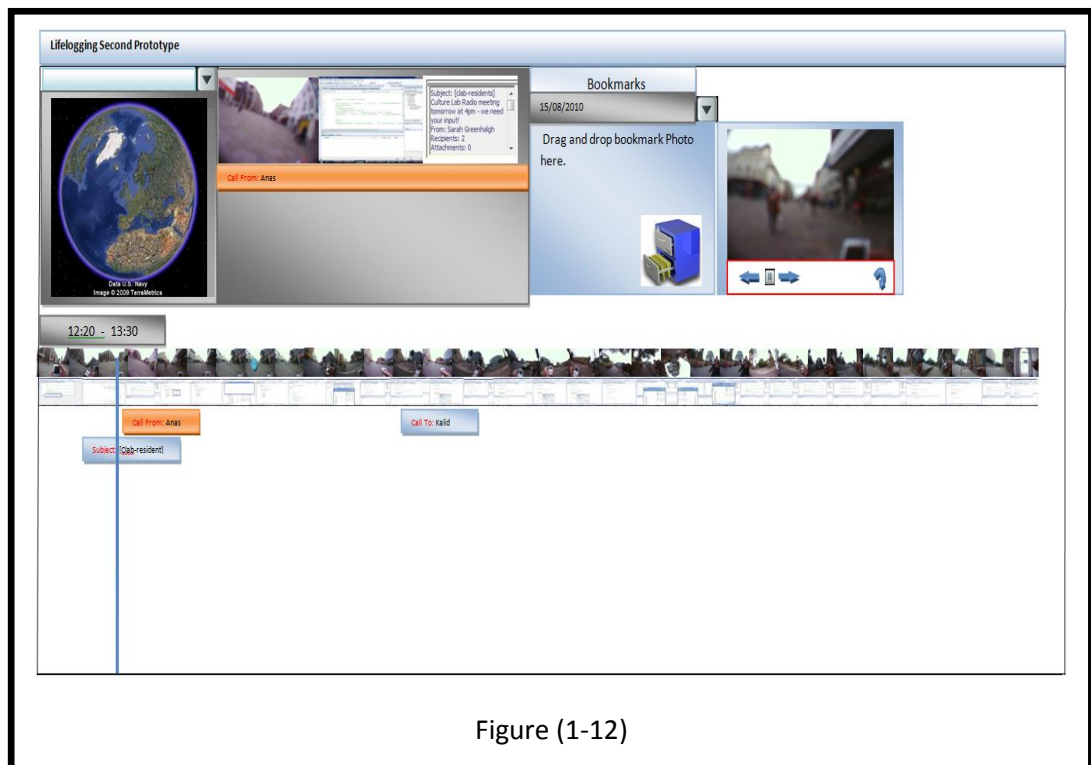


Figure (1-12)

Accelerometer and electricity consumption will be added to this plan.

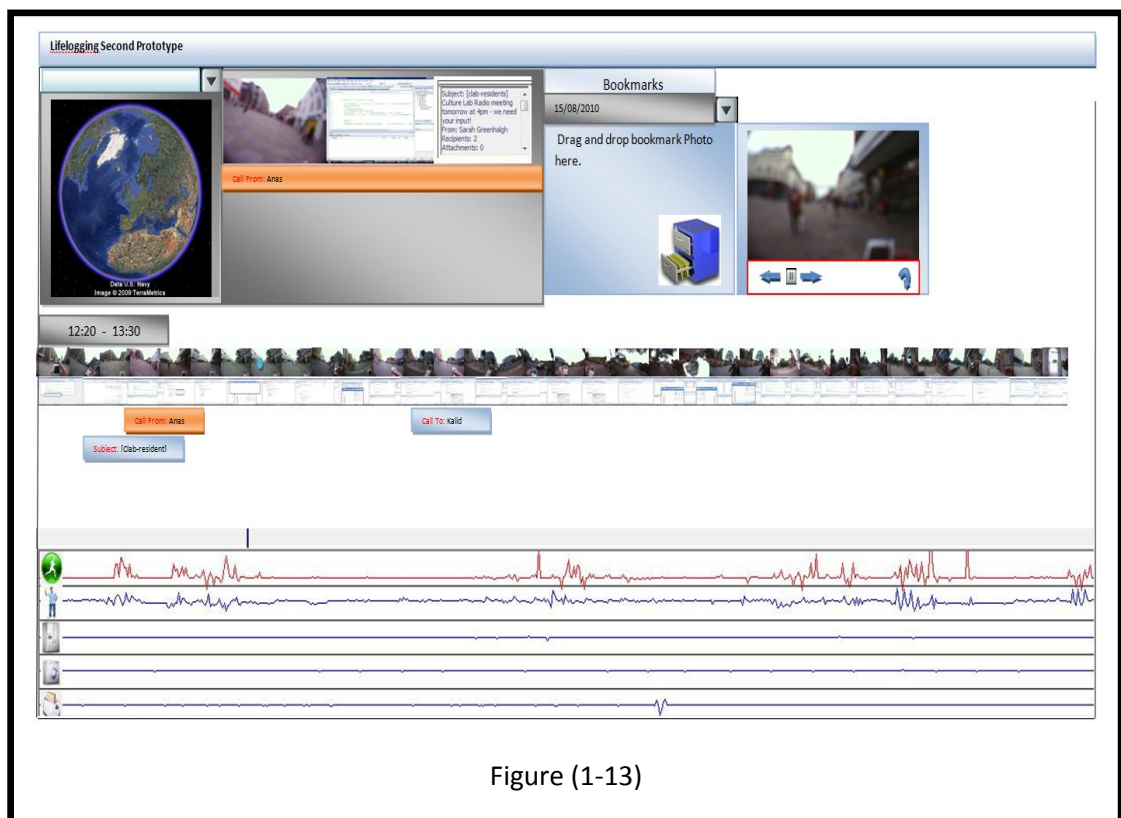
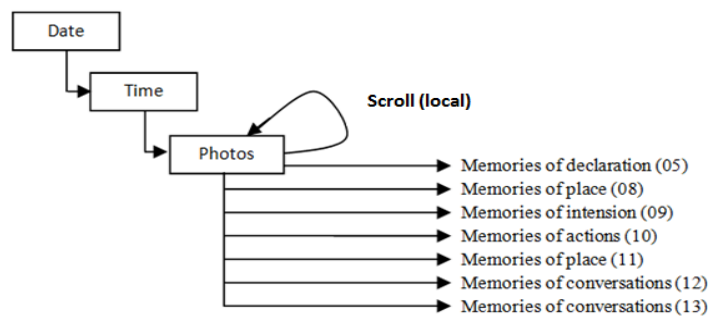


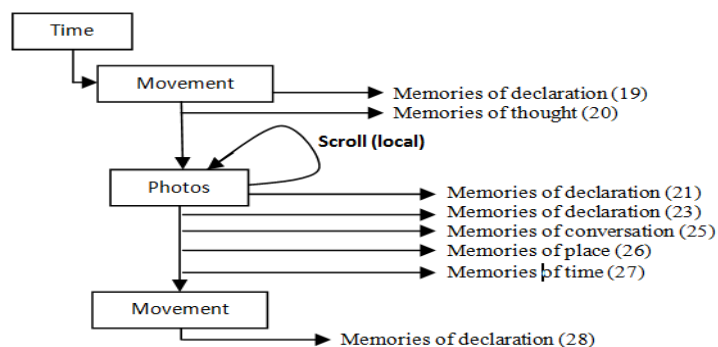
Figure (1-13)

Appendix E11

[05] "... one boy was talking to my son" ... [08] "... the school main gate was closed and many of children with their parents were outside of the schoolyard" ... [9] "... they were waiting for someone to come and open the gate" ... [10] "... the boy was trying to tell my son what happened" ... [11] "... that photo captured at the school kitchen" ... [12] "... one friend told us about his story with the Pizza" ... [13] "... he said it was big surprise for my house mate ... he thought I plan to have a party"

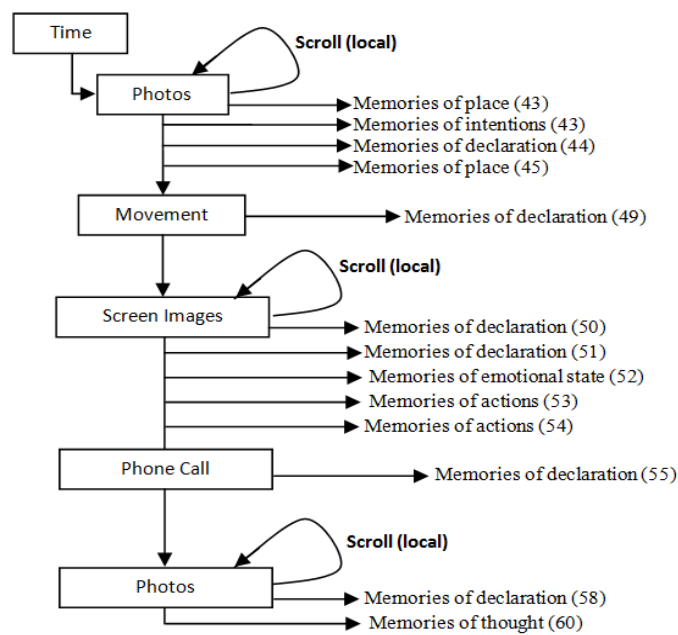


[19] "... that is the front door movement ... there were no photos before that action" ... [20] "... I wear the camera, but I did not switch it on" ... [21] "... the next photos show the way to the school ... the Virtual Google earth shows the path " ... [23] "... it was a little bit cloudy and the phone captured the GPS signal after approximately 6 minutes" ... [25] "... my daughter asked me why I am doing that" [26] "... those photos captured at the front door of the school"... [27] "... the gate opened just five minutes before 9 O'clock" ... [28] "... No movement for more than ten minutes" .

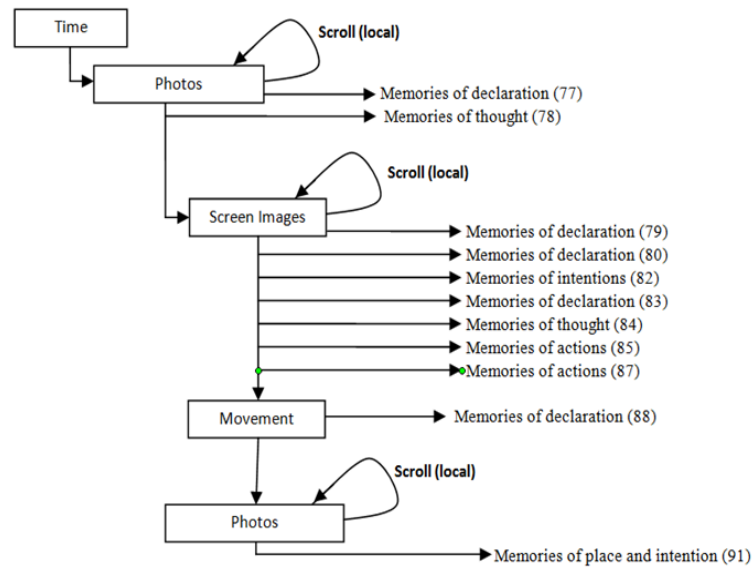


[43] "... I was in the shop at shoes part"... [43] "... I was looking for a new shoes for my son" ... [44] "... I checked all of the following photos, but I did not find any of them show that one I bought" ... [45] "... that photo shows the front door of culture lab and that one shows the lift interior" ... [49] "... I am sitting and working on my computer" ...

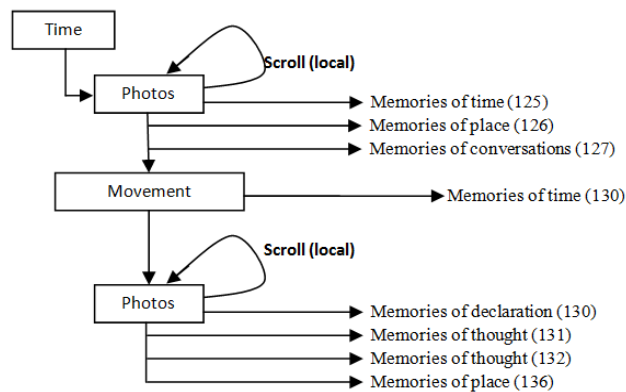
[50] "... the first ten minutes shows I was working on my computer ... I was checking the email Inbox" ... [51] "... that email was from my friend" ... [52] "...it was big surprise for me to hear that" ... [53] "... I did not reply him that morning" ... [54] "... that screen images show chapter four of my thesis ... I was updating that chapter" ... [55] "...that phone call was from my friend ... I could not remember the reason of that call or any conversation" ... [58] "... one of the photos shows I was holding an external hard drive" ... [60] "... when he called me that morning he told me about that offer he found".



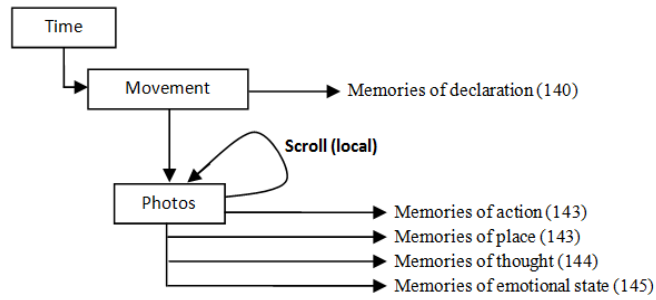
[77] "... that photo shows my friend's face and his computer ... he was pointing to the screen" ... [78] "... he was talking about something I could not remember" ... [79] "... that email there sent by the computer science postgraduate ... they ask about the progress report" ... [80] "... those images there show I was updating one chapter of of my thesis" ... [82] "... I was searching for progress report" ... [83] "... that image show the report document and that photo shows my friend was pointing to it" ... [84] "... he was asking about the progress report" ... [85] "... those images there show I was serving the internet again ... I was searching for qualitative methods papers" ... [87] "... I was working on the evaluation on my thesis" ... [88] "... I can see there a significant body movement" ... [91] "... that photo shows the coffee maker ... we went there for coffee".



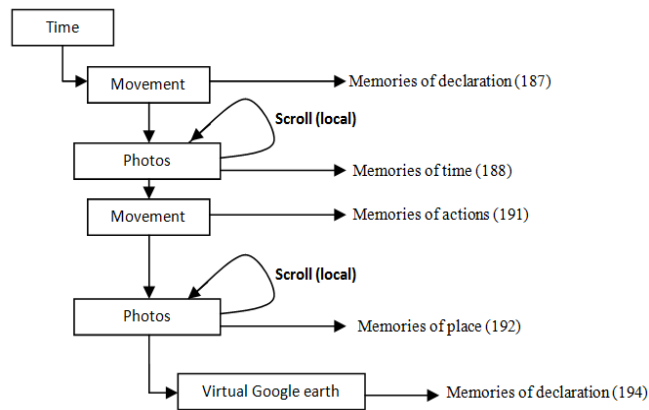
[125] "... I wear the camera and started capturing the photos at about 08:05 am" ...
 [126] "... I was in the kitchen" ... [127] "... I could not remember any conversation that happened at breakfast time" ... [130] "... that is the front door movement and that is the time when we went out" [130] "... that photo shows my neighbours children also come out to at the same time" [131] "... one of them is my son classmate" ... [132] "... she tried to talk to him many times, but he did not answer her" ... [136] "... those photos show the schoolyard".



[140] "... In the next hour I found a long significant movement of my body and hand" ...
 ... [143] "... I walked to the Gateshead bank" ... [143] "... those photos shows me in the front of a cashier talking to the banker" ... [144] "... I requested a new bank statement to renew my visa" ... [145] "... the banker was very friendly, he always smiling".

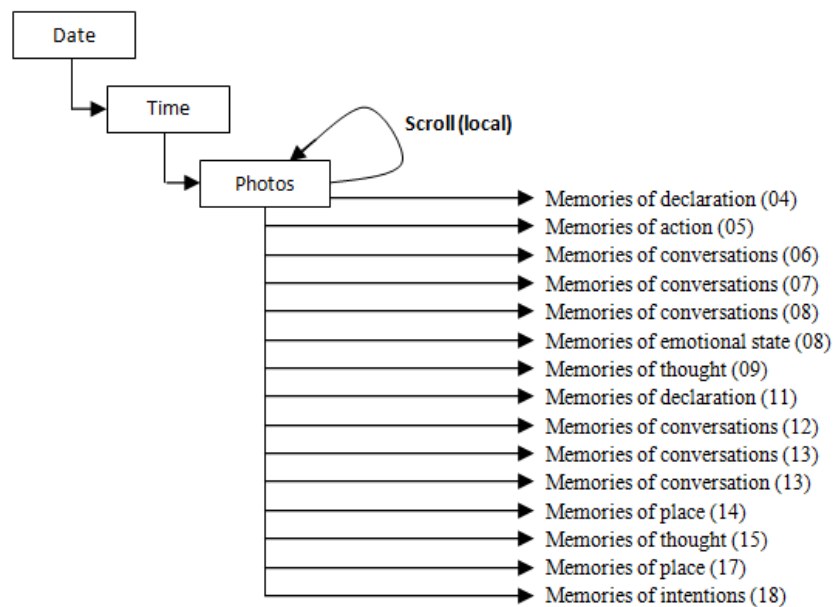


[187] “... there, I can see the significant movement of my hand” ... [188] “... that photo shows my laptop bag ... it was home time” ... [191] “... I stopped there to withdraw some money from the cash machine”... [192] “... that photo shows the metro station” ... [194] “... almost of the photos captured in the train take to the GPS data except the last few ones”.



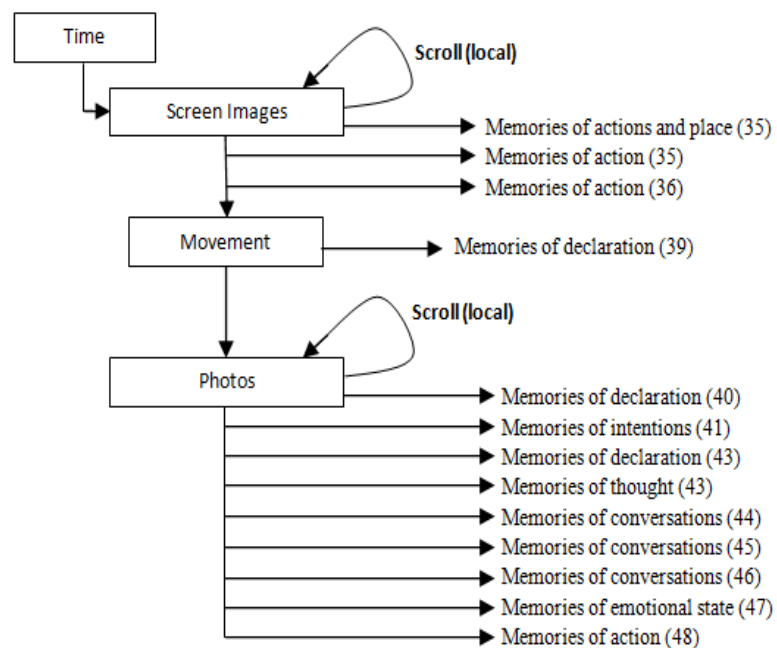
Appendix E12

[04] “ ... that photo here shows my children wearing their uniform and carrying their bags”... [05] “...the next photo shows both of the children were looking at the same direction” ... [06] “... they were talking about a car ... my son said it’s a racing car” ... [07] “... they asked me to buy it” ... [08] “... my son said you are a big enough to buy it” ... [08] “...I laughed too much” ... [09] “... they did not stop talking about that car until they arrived their school” ... [11] “... this photo there shows my son looking at the new construction of building” ... [12] “... he said that building should be a University” ... [13] “... I asked him, why?” ... [13] “... he said its very big building” [14] “...Those photos show many children with their parents standing outside of the school” ... [14] “... when we arrived I saw the gate was closed” ... [15] “...That never happened before” ... [17] “... those photos there captured in the school” ... I dragged and dropped some of them to the bookmarks” ... [18] “... these photos her shows I am in my way to the University”.



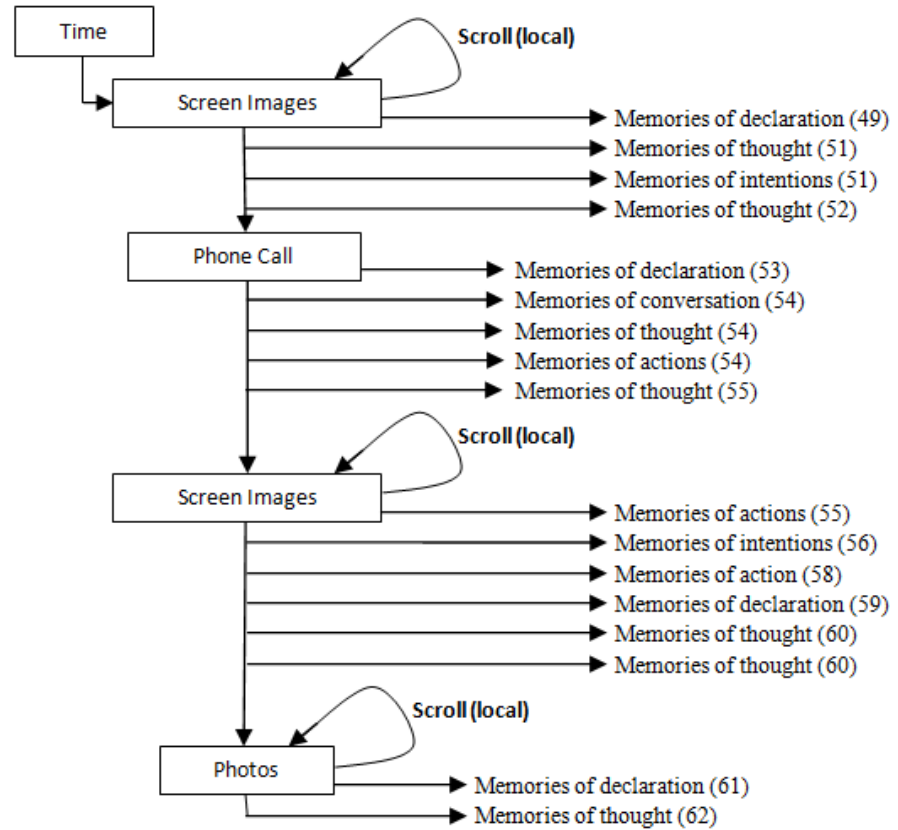
[35] “... here, I am in the Lab working on the computer” ... [35] “... I was checking the email inbox” ... [36] “... and there, I was serving the internet”

... [39] “... that is my body and hand movements” ... [40] “... one friend appear in that photo, he was talking to me” ... [41] “... that is my food bag ... we were going to have lunch” ... [43] “... we used the stairs to the kitchen” ... [43] “... we found another friend there” ... he appeared [44] “...we talked about the work after graudation” ... [45] “...we talked about different companies” ... [46] “... one friend told us about his house mate when he saw him carrying dozens of pizza” ... [47] “ ... he was funny ... I dragged and dropped some of these photos to BookMarks” ... [48] “... we left the kitchen”.

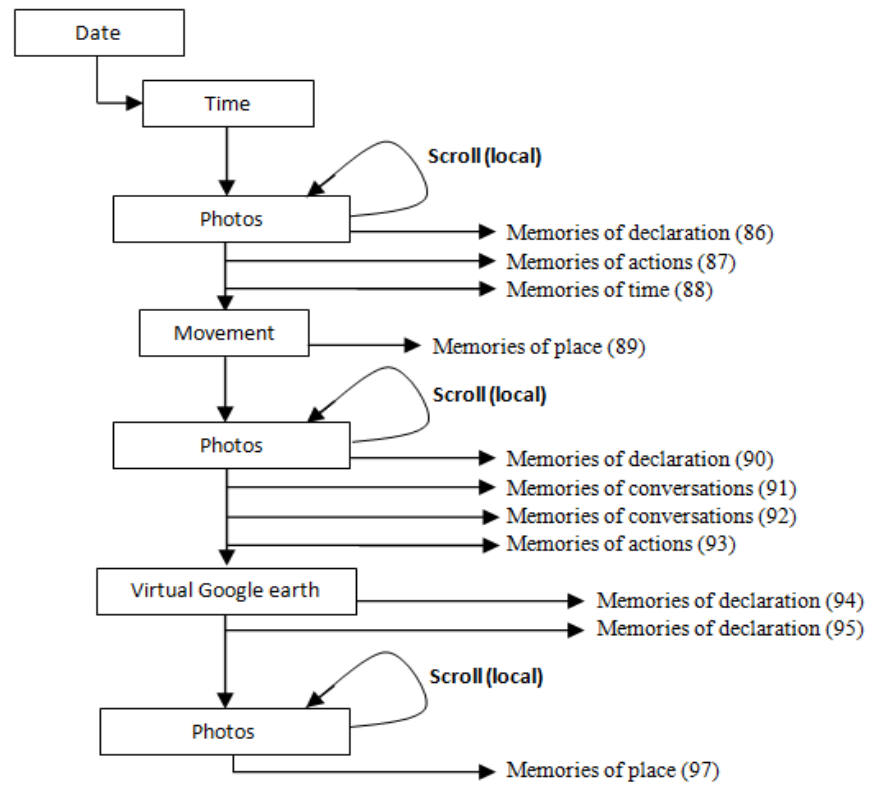


[49] “...that email was from my friend ... he asked me about how to get acceptance from the UK Universities” ... [51] “...we have been studied at the same University” [51] “... he plan to finish his study in the UK” ... [52] “... he works for petroleum company” ... [53] “...this phone call is from my wife” ... [54] “... she told me our daughter hurt herself in the school” ... [54] “... she plumbed her head” ... [54] “... she slept after arriving home until neigh” [55] “... when I back home I found her still sleeping”. [55] “...these images show I was searching the internet” ... [56] “... I was looking for landline phone for my house” ... [58] “... that is the one I bought” ... [59] “... that screen image shows the delivery date and the product location” ... [60] “... I received that order in about only six days” ... [60] “... the quality

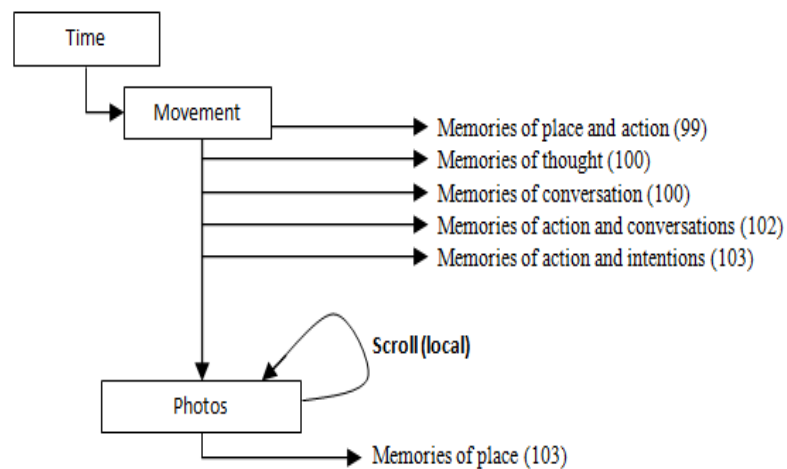
of that product is not very good” ... [61] “... that photo there shows my friend face and his computer screen” ... [62] “...he was looking for LCD display screen for his computer” .



[86] “... I can see the food that we had, but I cannot remember any conversation” ... [87] “... that photo there shows I was helping my son to wear his coat” ... [88] “... In these ones the children are dressed up and ready for the school” ... [89] “... that photo shows the front door of my house” ... [89] “... that is the front door movement” ... [90] “... that photo shows my son bag “ ... [91] “... he said he do not like his old bag anymore” ... [92] “...he said he do not like the colour” ... [93] “... the children stop and they did not cross the road without me” ... [94] “... the path and the photos show we returned back again to the house” ... [97] “... that photo there captured at the school” .

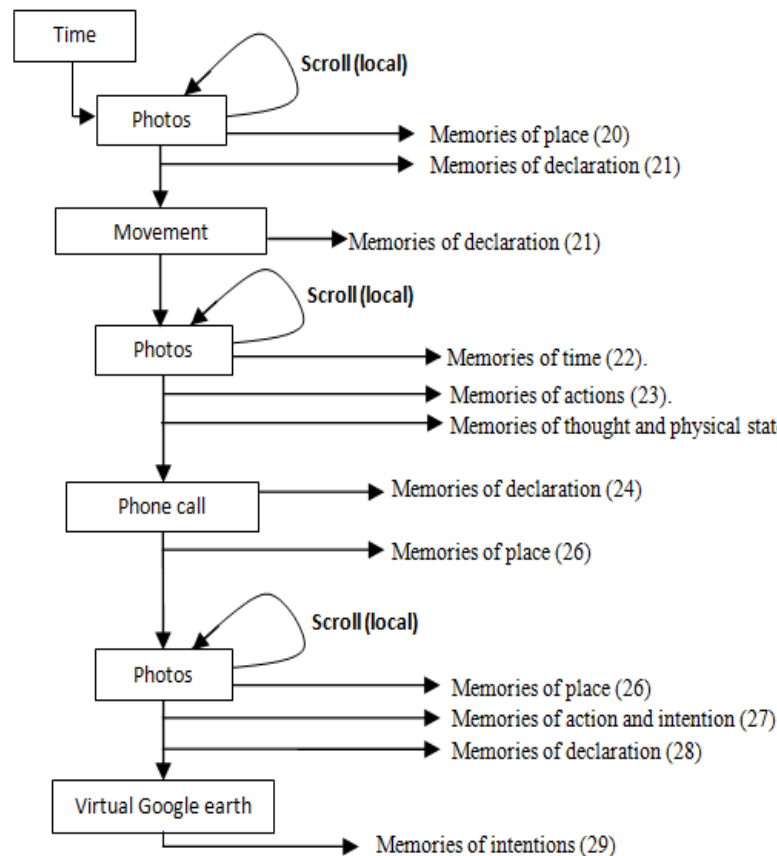


[99] "...there, I was in the bank no movement of body" ... [100] "... I request a new bank statement from the banker" ... [100] "... I can remember the whole conversation" [102] "... the banker take my card details and he said I will receive my bank statement within ten working days" ... [103] "...I started moving again ... my destination was the University" ... [103] "... those photos here shows the culture lab main entrance".



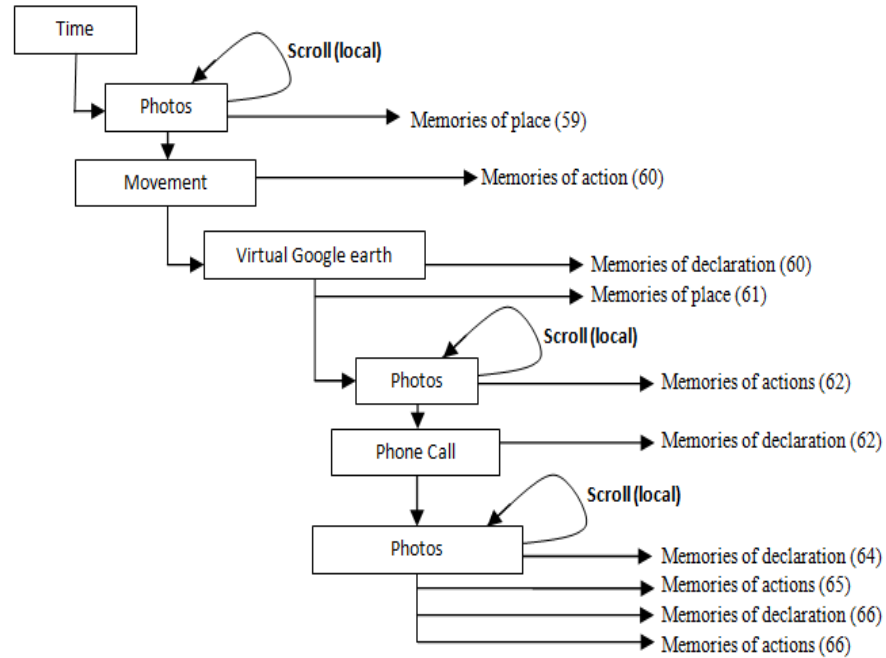
Appendix E21

[20] "... first photo was taken at the kitchen" ... [21] "... there, I can see the photos of the toaster, kettle, fridge and the movement of each of them" ... [22] "... nobody was in front of me when I had my breakfast" ... [23] "... that day I prepared my breakfast alone" ... [24] "... my wife was little bit sick " ... [24] "... that phone calls was to the GP" ... [24] "... I made an appointment for her" ... [26] "... that photo shows my house front door, and the next one's shows the satires" ... [27] "... I went back, I left my smart card and my mobile phone in the other coat" ... [28] "...thas photo shows my coat" ... [29] "... that is my path to the University".

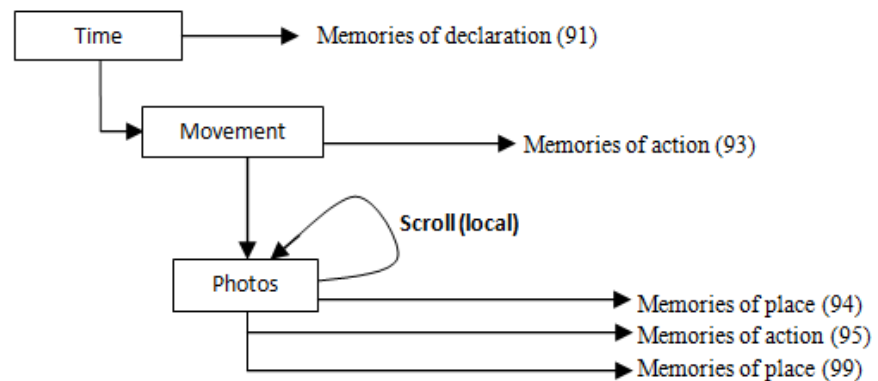


[59] "... those photos taken in the lift" ... [60] "... that is my body and hand movement ... I was walking" ... [60] "... the whole path and the photos appears on the virtual Google earth" ... [61] "... this photo captured at Tyne bridge" ... [62] "... I went to the shop to buy some food" ... [62] "... that is my phone call to my wife" ... [64] "... from the photos I can see the trolley

and almost of the stuff that I have bought from the shop” ... [65] “... there, I was checking out” ... [66] “... that photo shows the checkout machine” ... [66] ... I paid by the credit card not cash”

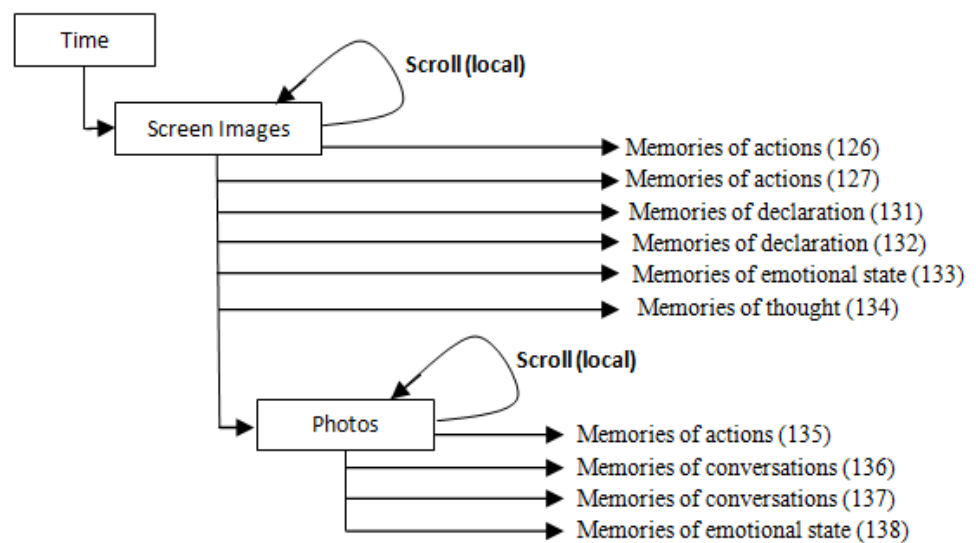


[91] “... I started wearing the camera at 08:00 O’clock until 20:00 O’clock” ... [93] “... at 08:40 I can see that I was walking” ... [94] “... my daughter was with me at the front door” ... [95] “... she was waiting for me to open the door to go outside” ... [96] “... the second photo shows my kids carrying their lunch bags” ... [96] “... the third photo shows the front door of the school”.

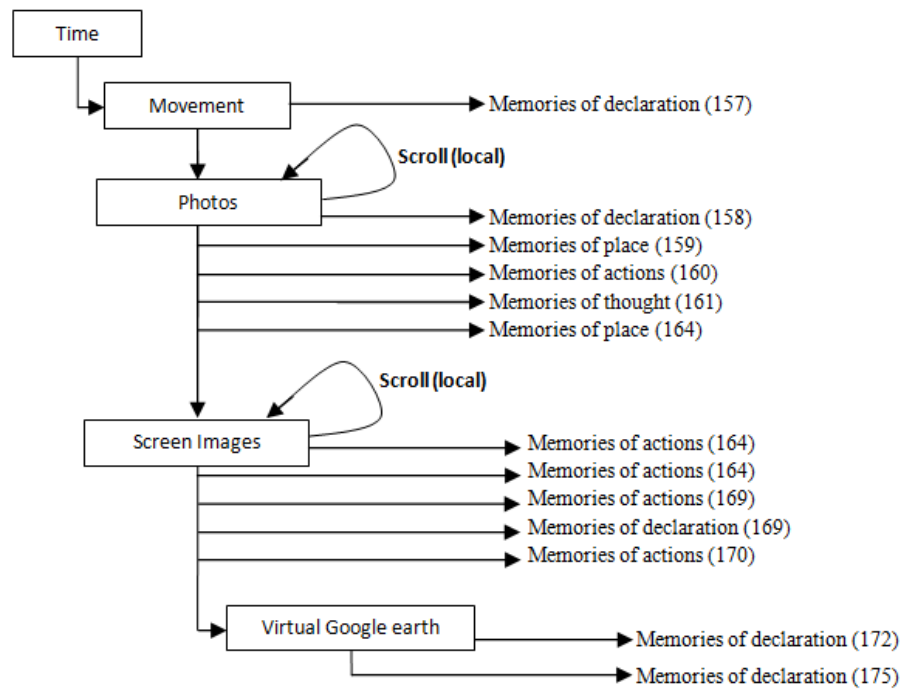


[126] “... here, I turned on the computer, and started working” ... [127] “... I opened my diary” ... [131] “... that email I received from one friend

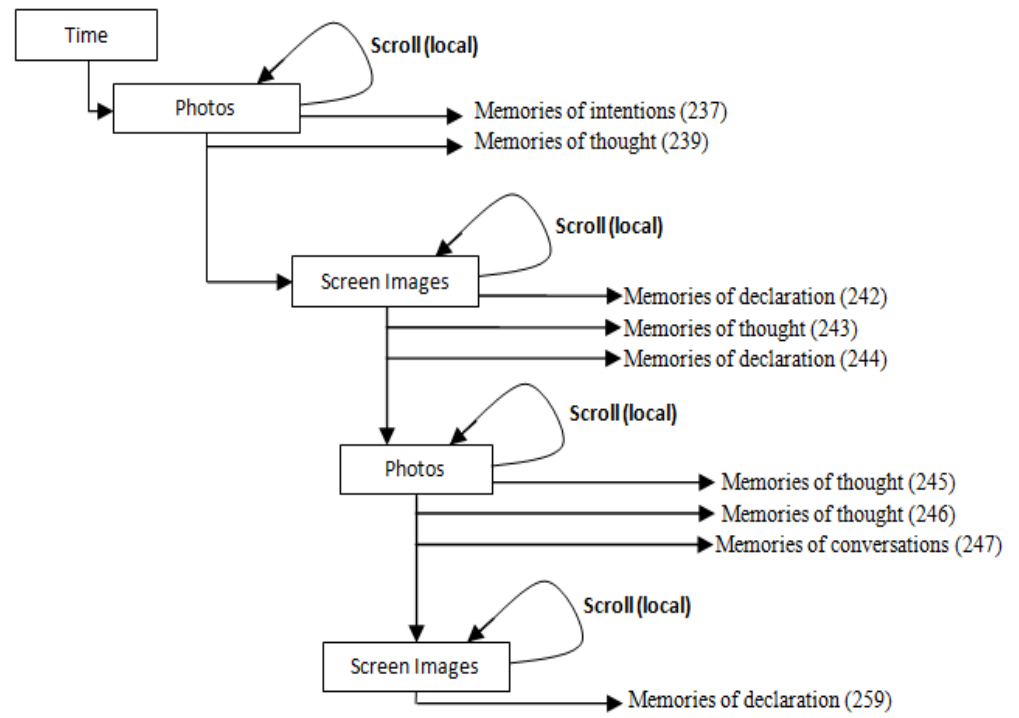
asking me about how to create dynamic website and the prices of it” ... [132] “... here my email which I sent to him includes some web sites, I explained to him where to go” [133] “... that day I was a little busy and nervous” ... [134] “... my email was short and does not include any explanations” ... [135] “... those photos there show I was talking to one of my colleagues” ... [136] “... he asked me about my country news” ... [137] “... he said he heard some details about what I told him” ... [138] “...I was very happy to see some people care about others problem and share them their happiness”.



[158] “... I was standing in front of my office” ... [158] “... my food bag appears in one photo” ... [159] “... I found one girl in the kitchen” ... [160] “... she did not answer me when I said hello” ... [161] “... I repeated that with a big voice, but she did not answer me again” ... [164] “... here I am in the office again” ... [164] “... I was checking my email Inbox” ... [169] “... I was working on my thesis again ... I spent a long time on that without movement” ... [170] “... there, I switched off the computer, it's home time” ... [172] “... that is my path on the virtual Google earth” ... [175] “... I continued my way to the shop”.

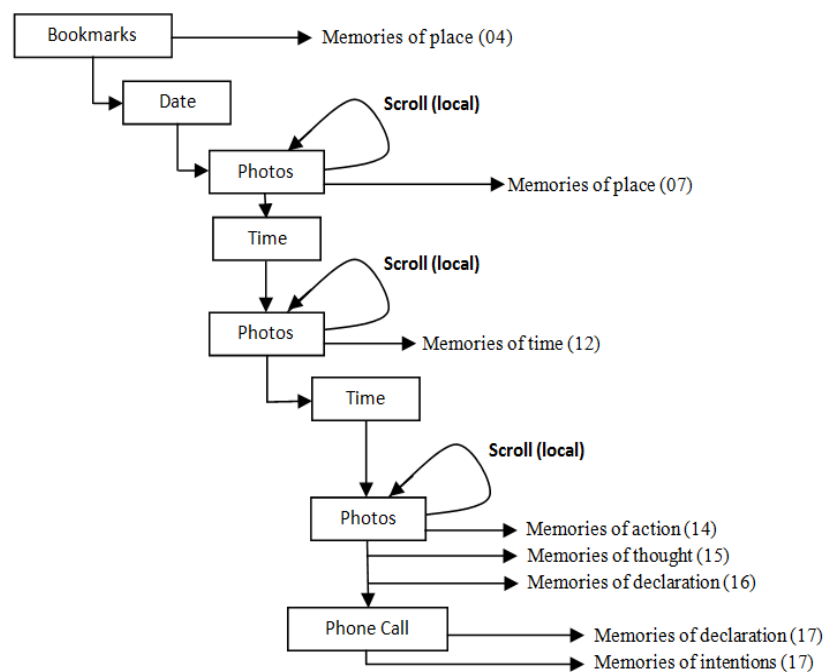


[198] "... that path shows my way to the University" ... [198] "... In that photo I can see an old woman and man in front of me" ... [199] "... the woman was moving hardly" ... [199] "... It was surprising me when that man said Mum watch out" ... [200] "... It was a nice feeling" ... [201] "... here I can see my body and hand movement, also the path is appearing on the Google earth" ... [203] "... that phone call was to my wife" ... [203] "...I asked her to check whether my pocket bag is there or not" ... [204] "... she told it's on the TV table" ... [205] "... I went back home" ... [206] "... there, I was in the bus stop" ... [208] ...and there I was in the bus ... I sat in the front chair" [208] "...this photo here shows the guy who tried to get in the bus with invalid ticket" ... [209] "...he talked a lot with the driver" ... [210] "... at the end the drive asked him to buy new ticket or to leave the bus" ... [211] "... he shouted and got out" ... [211] ... here, I was at high street" ... [212] "... the street looks wet and few people appear in the photos".

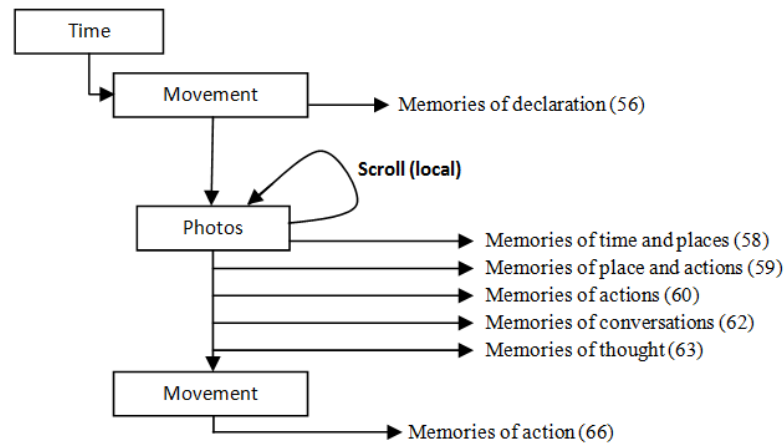


Appendix E22

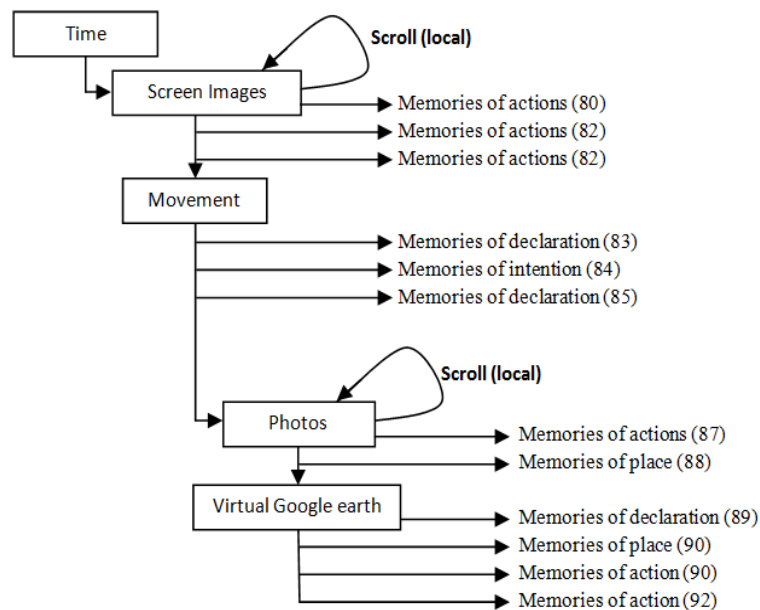
[04] “... I moved directly to the bookmarks pane calendar to check if there is any photo there” ... [07] “... the first photo I found shows my friend in the kitchen” ... [12] “... I had lunch with my friend, but I cannot remember any conversation” ... [14] “... the next photos I found in the bookmarks captured in the shop when I was checking out” ... [15] “... two times I checked out” ... [16] “... in the second checkout I can see only a juice on the checking belt” ... [17] “... that phone call was from my wife” [17] “... I went back for the juice after my wife call”.



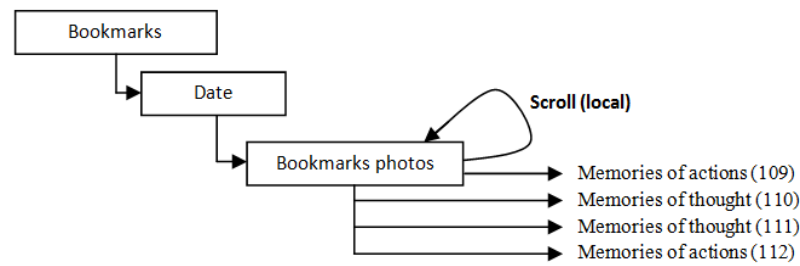
[56] “... I found significant movement in the next hour” ... [58] “... those photos show my cup, my lunch bag, the stairs, and the kitchen” ... [59] “... that photo shows one friend in the kitchen there he was alone having his lunch” [60] “... many photos shows his face was talking to me” ... [62] “... he told me he watch the news twice every day” ... [63] “... he found that news interesting for him to share” ... [66] “... that movements and the photos show I back to my office”.



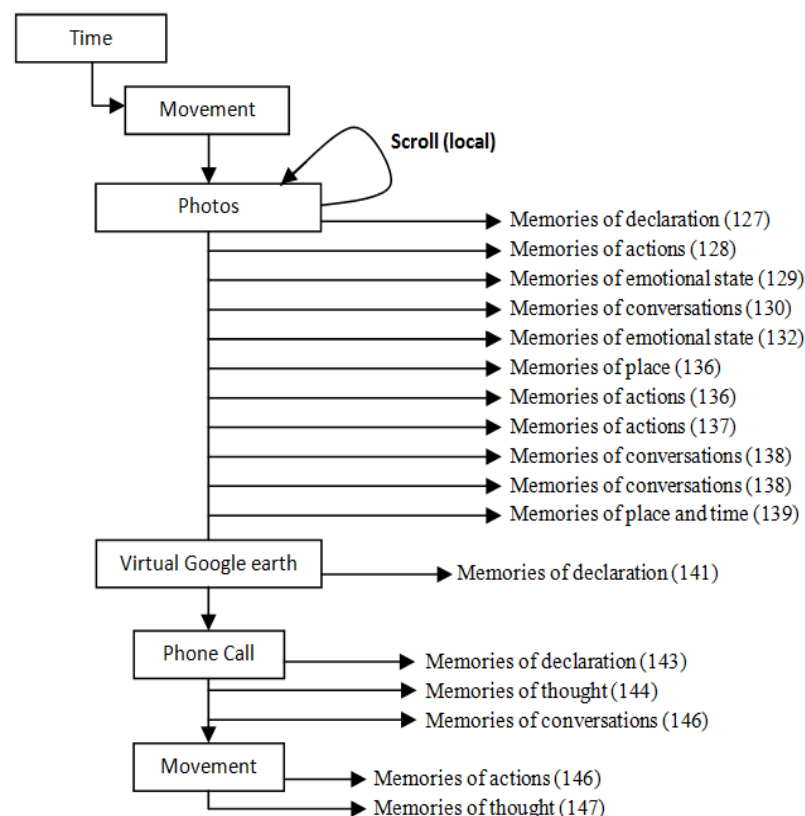
[80] "... I spent the whole of that day working on that document and skimming some papers" ... [82] "... I served the internet searching for any related information" ... [82] "... I checked the news many times" ... [83] "... at 19 O'clock I can see there a long significant movement of both my hand and body" ... [84] "... I was in my way to home" ... [85] "... the movements started approximately at 18:57 O'clock" ... [87] "... I switched off the light" ... [88] "... the next two photos taken at the lift" ... [89] "... there is my path and the photos on virtual Google earth" ... [90] "... those photos taken at the high street" ... [90] "... that photo shows the cash machine I withdraw some money" ... [92] "... I walked to my home".



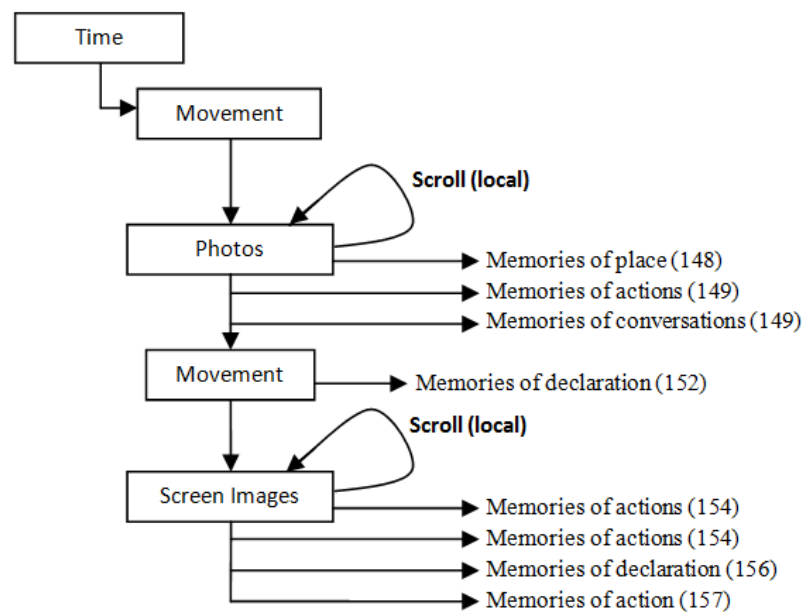
[109] "... that photo shows my son talking to one child" ... [110] "... no one was wearing the school uniform" ... [110] "... it was the first day of the school" ... [111] "... and it was the first day of the first class of the primary school for my son" ... [112] "... the second photo shows my son is looking at his new teacher".



[127] "... it was heavy rain" ... [128] "... that photo was taken when I sat down to change my daughter shoes she was wearing them opposite" ... [129] "... I laughed very much when I saw that" ... [130] "... those photos here show the children did not wear their uniform" ... [132] "... my son was very happy of that" ... [136] "... those photos show my son class room" ... [136] "... the teacher shows the children where to put their coats and bags" ... [137] "... my son teacher was talking to me" ... [138] "... she asked me about my son lunch" ... [138] "... I told her his food in his bag and he can manage to do everything by himself" ... [139] "... that photo shows the main entrance of the school it was captured exactly at 09:00" ... [141] "... that line on the virtual Google earth shows my path from the school to the University" ... [143] "... that phone call I received from my uncle" ... [144] "... it was the first time he calling me at morning" ... [146] "... he told me the phone networks not always available" ... [146] "... no movement while I was talking to him" ... [147] "... the sound was not clear enough".

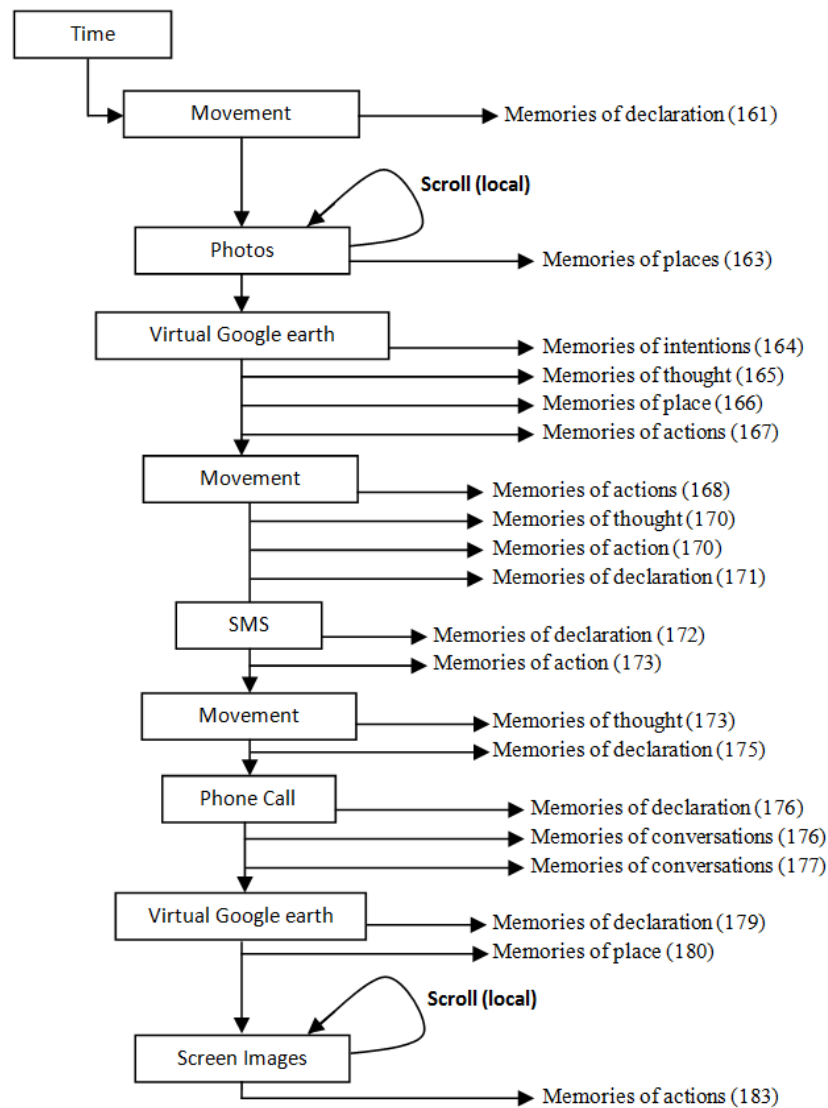


[148] “... those photos there show me in the shop” ... [149] “... I was holding a screwdriver it was for my friend” ... [149] “... he asked me many times for that kind of special screwdriver to fix his play station” ... [152] “... there I can see no movements of my hand and my body” ... [154] “... those images show I was checking my email Inbox” ... [154] “... I opened that email it was from one friend” ... [156] ... my friend asked me to direct him to some useful papers and useful web sites explain how to create dynamic websites” ... [157] “... I replied him I found what he was looking for”.

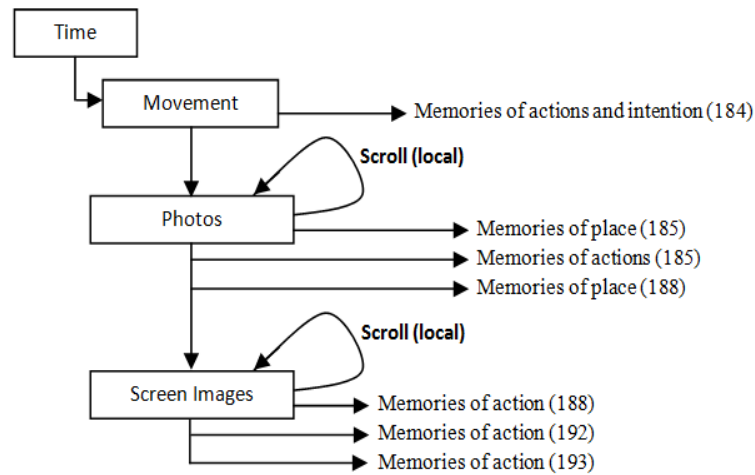


[161] “... when I checked the next few hours I found significant movement of my body and hand” ... [163] ... that photos shows the student Union building” ... [164] “... I moved to the virtual Google earth to check my path and the photos, I found I was going to the hospital” ... [165] “... I had an appointment there” ... [166] “... the last photo shows the main entrance of the hospital” ... [167] “... there, I turned off the camera and kept it in my pocket” ... [168] “... in the hospital I moved many times” ... [170] “... the waiting room was too crowded” ... [170] “... I waited for more than 30 minutes” ... [171] “... and then the Nurse called me and asked me to wait for few second until she call me again” ... [172] “... I waited for more than 7 minutes” ... [172] “... that SMS I received from the landlord” ... [173] “... there, I moved again for short time, I think it was when the doctor called me” ... [175] “... I spent exactly 12 minutes with the doctor” ... [176] “...that phone call was to the landlord” ... [176] “... I told him I will be at home Saturday morning” [177] “... he said he will send someone to fix the boiler” ... [177] “... there I turned ON the camera again” ... [179] “...I used the same path when I back to the

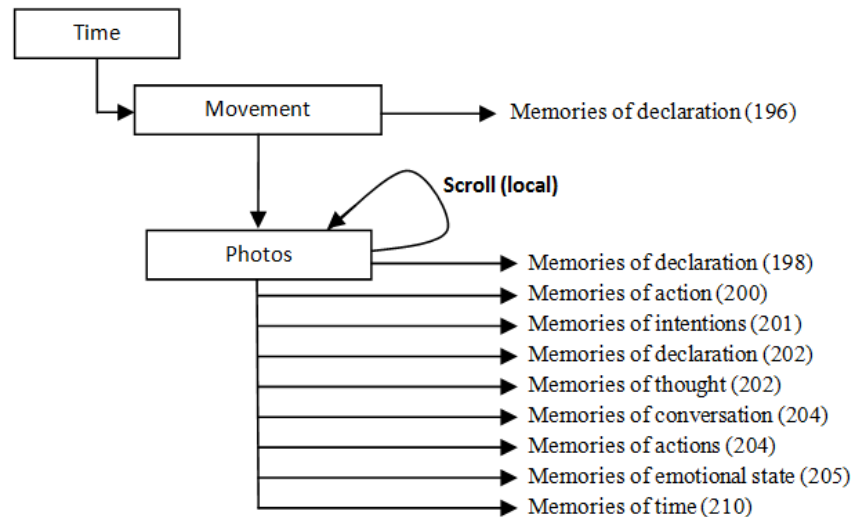
lab” ... [180] “... those photos show my office” ... [180] “... I started working on the computer [183] “... I spent more than five minutes reading the news”.



[184] “... that is my movement I was going to the kitchen” ... [185] “... that photo show there was only one girl in kitchen” ... [185] “... I did not talk to her and she did not appear in the next photos” ... [188] “... that photo taken in my office” ... [188] “... I started again working on the computer that is the new paper I found” ... [192] “... I spent a long time reading that paper”... [193] “... some screen images show different parts of my thesis”.

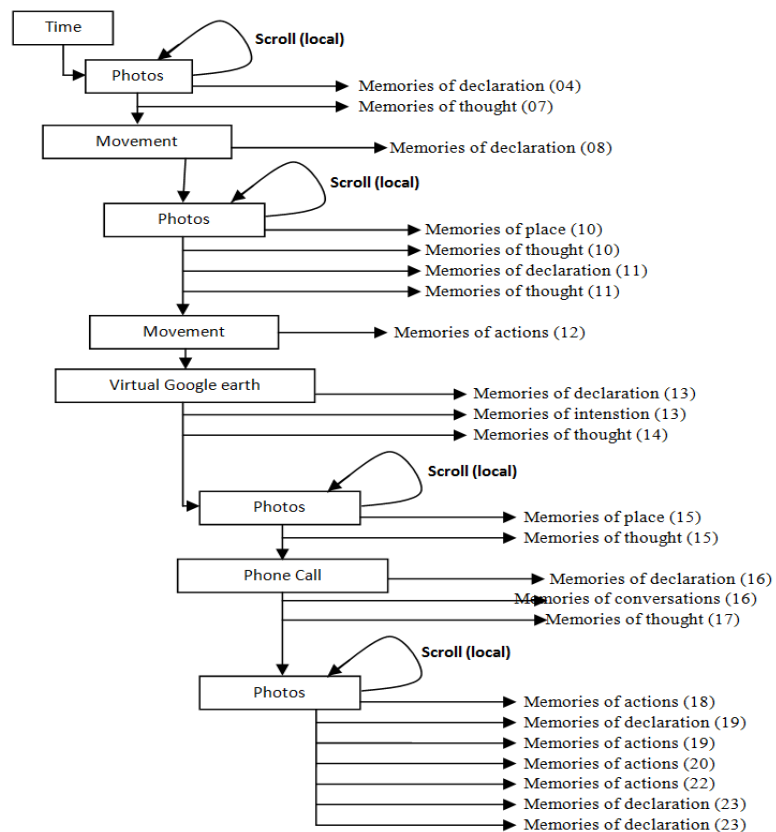


[196] "... I checked the next hours searching for long period of movement" ... [198] "... the first photo shows my computer was closed" ... [200] "... that photo shows my bag" ... [201] "... I was in my way to the house" ... [202] "... that photo shows one man was talking to me" ... [202] "... I never saw that face" ... [204] "... he asked me about one hotel" ... [204] "... I pointed the way for him, but when I looked back I saw that man was walking in the opposite direction" ... [205] "... I laughed to much of that I think he was drunk" ... [210] "... those photos taken out of the shop it was dark" .

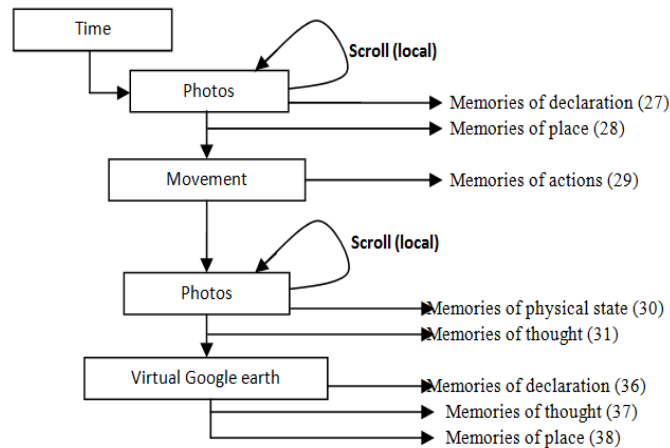


Appendix E31

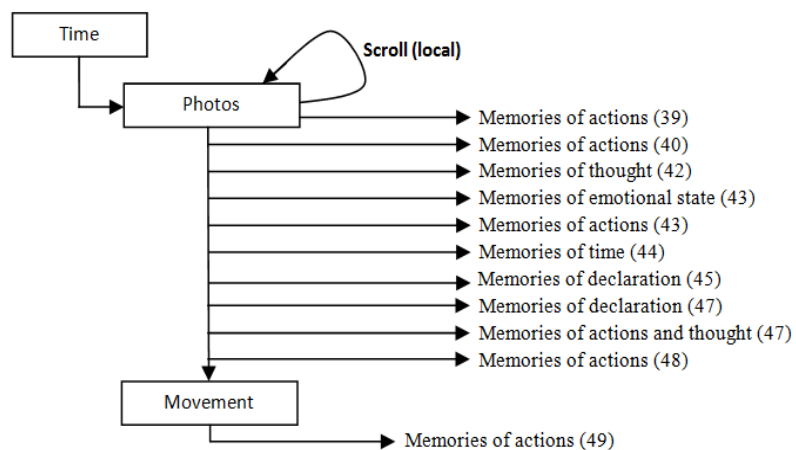
[4] "... I started capturing the photos at 23:00 for two hours and then I stopped" ... [7] "... that day I went to London" ... [8] "...I found a significant movement of my body and hand" ... [10] "...those photos there shows the bus stop" ... [10] "... nobody was in the stop except me" ... [11] "... that photo shows the bus timetable" ... [11] "...the bus just passed and the next one need long time to come" ... [12] "... I can see my hand and my body movements ... I was walking" ... [13] "... that is my path there on the Virtual Google earth" ... [13] "... my destntaion was the Royal station" ... [14] "...the weather was very nice" ... [15] "... those photos taken at the Royal station" ... [15] "... I arrived there before my freined" ... [15] "... that phone call was to my friend" ... [16] "... he told me he is still at the bus stop waiting for the bus" ... [17] "... although it was normal day not weekend I saw many people were walking" ... [18] "... that photo shows my ticket ... I was checking it before the bus arrived" ... [19] "... that shows my friend face" [20] "... he was talking to me" [22] "... we moved to the bus there" ... [23] "... that photo shows the queue" ... [23] "... that is my chair where I sat the whole journey".



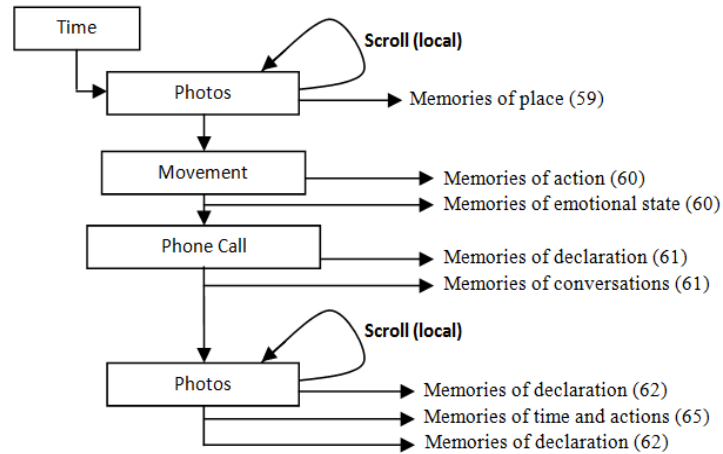
[27] "... these photos captured in London ... it was still little bit dark" ...
 [28] "... that is the Victoria station" ... [29] "... there, I was walking out of
 the station" ... [30] "... I was very tired" ... [31] "... I can remember exactly
 what happened at that moments" [36] ... it was another short routes to our
 destination" ... [38] "... it was sunny day" ... [38] ... these photos here
 captured at the Hyde park.



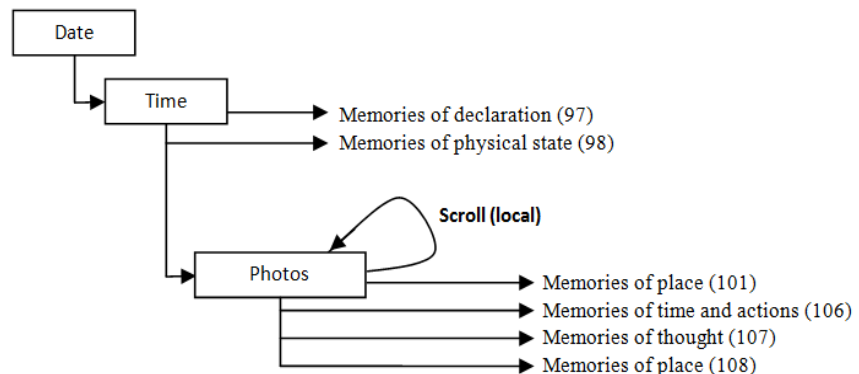
[39] "... there is a gap of the photos over there ... I went to the Toilet" ...
 [40] "... that photo shows my friend was waiting for me" ... [42] "... he
 showed me the olive tree" ... [43] "... it was big surprise for me" ... [43]
 "... I shouted, I could not believe my eyes" ... [44] "... those photos show
 we had a breakfast" ... [45] "... that photo shows some food we had" ...
 [47] "... we spent a long time having our breakfast" ... [47] "... we did not
 sit on chairs, they were wet" ... [48] "... some people were swimming in the
 river" [49] "... I was walking".



[59] “... those photos here captured at Hyde Park as well” ... [60] “... I was sitting neither body nor hand movement” ... [60] “... I can remember my felling at that time” [61] “... that phone call there to my wife” ... [61] “... I told her about the journey” ... [62] “... that photo shows my friend face” ... [65] “... we had a lunch together” [65] “... that photo shows some of our food”.

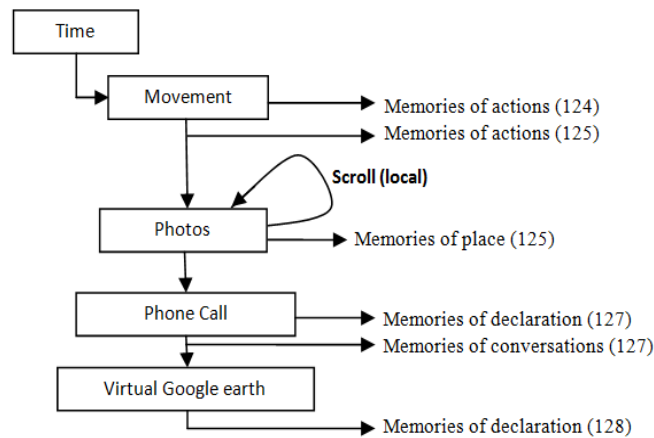


[97] “... I started capturing my photos at 11:00 am” ... [98] “... I was very tired, I could not wake up until approximately 10:30 am” ... [101] “... the first photo captured at home, the second one captured out door, the third one captured in the post office, and the forth one was taken in the shop” ... [106] “... those photos there show I had a breakfast with my wife” ... [107] “... that day I did not take the children to the school” [108] “... those photos there show my house down stairs”.

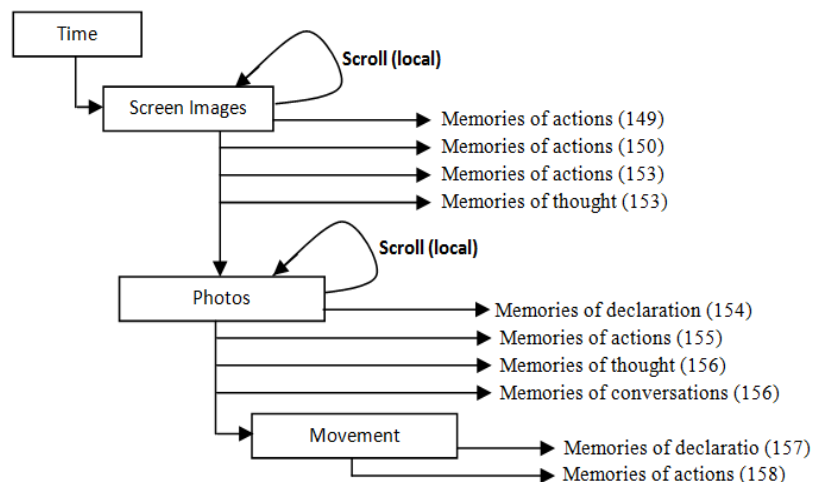


[124] “... there, I was walking” ... [125] “... I stopped there for short time” ... [125] “... when I checked the photos of that period of time I found myself in the front of the cash machine” ... [127] “... that phone call is from my friend” ... [127] “... I could not remember any conversations or the reason of

that call” ... [128] “... those photos there and the path on Virtual Google earth showing my way to my house”.

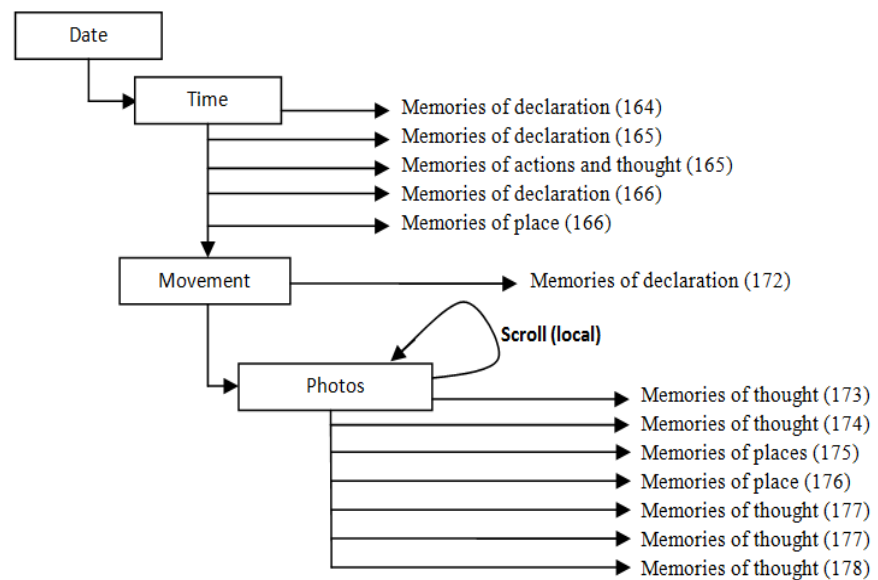


[149] “... there, I was working on my computer ... I worked for a long time”
 ... [150] “... I was checking may email inbox” ... [153] “... those images
 there show I was reading a paper” ... [154] “... I spent a long time on it” ...
 [154] “... those photos there show my son” ... [155] “... he was playing
 games on the computer” ... [156] “... the game was new for him and each
 time he was calling me to help him” ... [156] “... I asked him to watch
 cartoon DVD’s instead of the games” ... [157] “... there I can see some
 movements in the kitchen” ... [158] “... it was my wife, she was preparing
 some tea”.

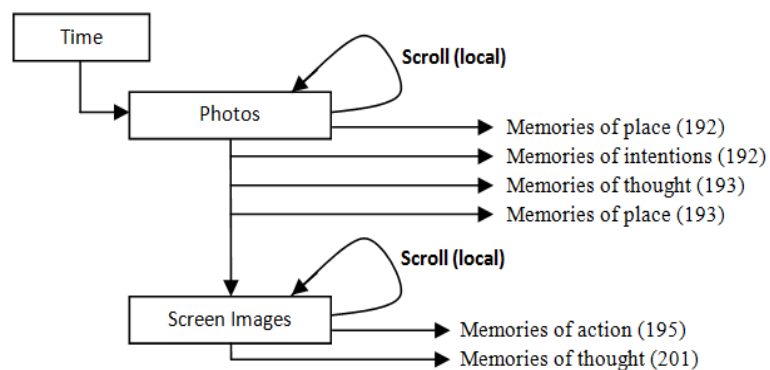


[164] “... I started capturing the photos from 08:00 am until 08:08 pm” ...
 [165] “... there were many gaps in the photos” ... [165] “... I turned off the
 camera many times” ... [166] “... I found no photo in the first quarter of the
 hour” ... [166] ” ... the second photo captured at home ... the third and the

fourth ones were captured put side” ... [172] “... that is the front door movement” ... [173] “... that is the headmaster of the school” [174] “... we arrived just in time” ... [175] “... those photos captured in the bus stop” ... [176] “... and those photos there captured in the bus” ... [177] “... that man and the woman in the front was argued loudly” ... [177] “... people was looking at them strangely” ... [178] “... they did not stop shutting until the driver asked them to stop that or get off from the bus” .

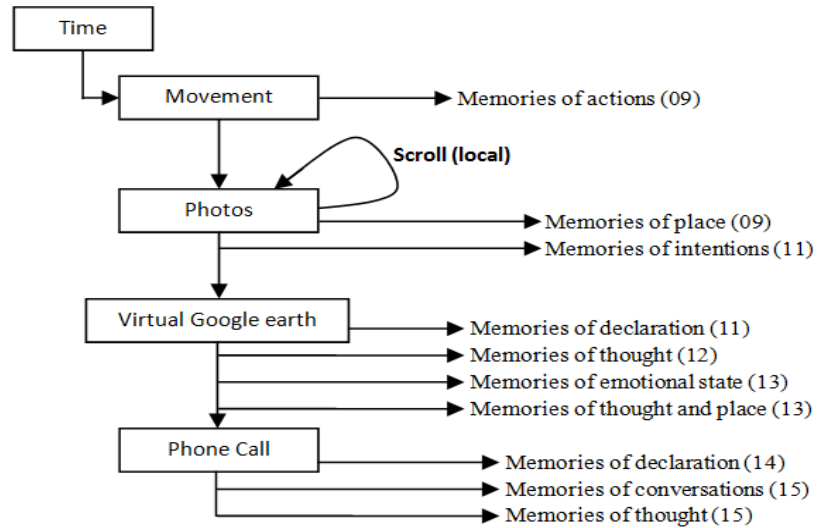


[192] “... I visited Vodafone shop” ... [192] “... I have been there to buy top up voucher” .. [193] “... I found one friend in front of me looking for phone offers” ... [193] “... that photo there shows the culture lab front door” ... [195] “... those images show that I was working on the computer” ... [200] “... there, I was improving chapter three of my thesis” ... [201] “... I was very busy that day” .`

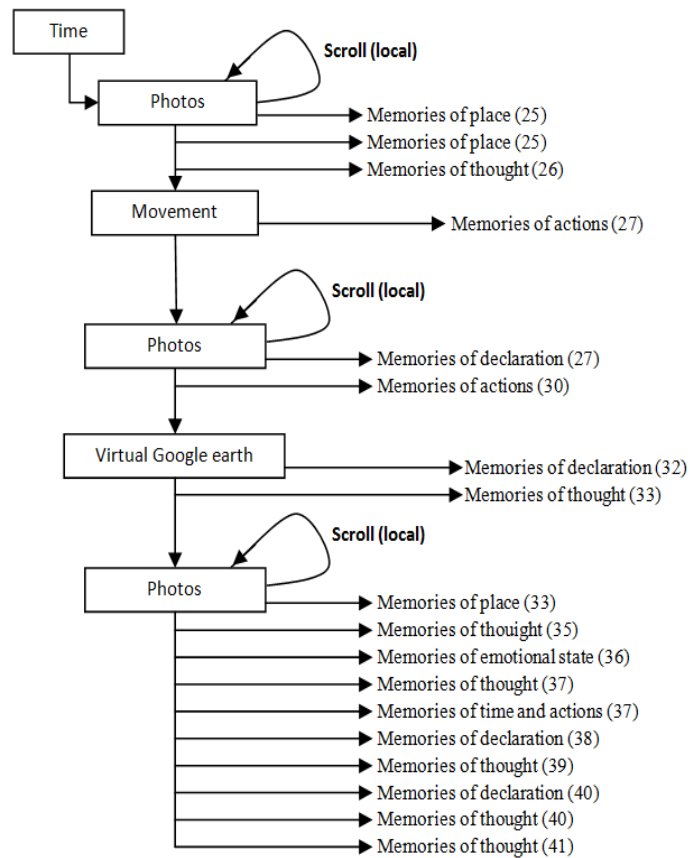


Appendix E32

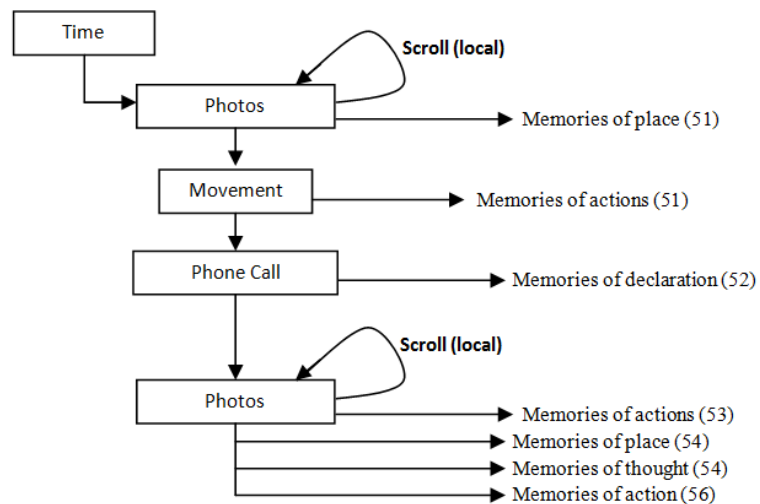
[9] "... I stopped after short walking" ... [9] "... that photo shows the bus timetable ... I was at the bus stop" ... [11] "... I decided to walk" ... [11] "... the path on the virtual Google earth shows the road I have been taken" ... [12] "... the weather was nice" ... [13] "... I felt the air full of oxygen ... I was very fast" [13] "... I arrived to the Mega bus stop before my friend" ... [14] "... that phone call was to my friend" ... [15] "... he said, he still at the bus stop waiting for the bus"... [15] "... it was normal working day, not weekend".



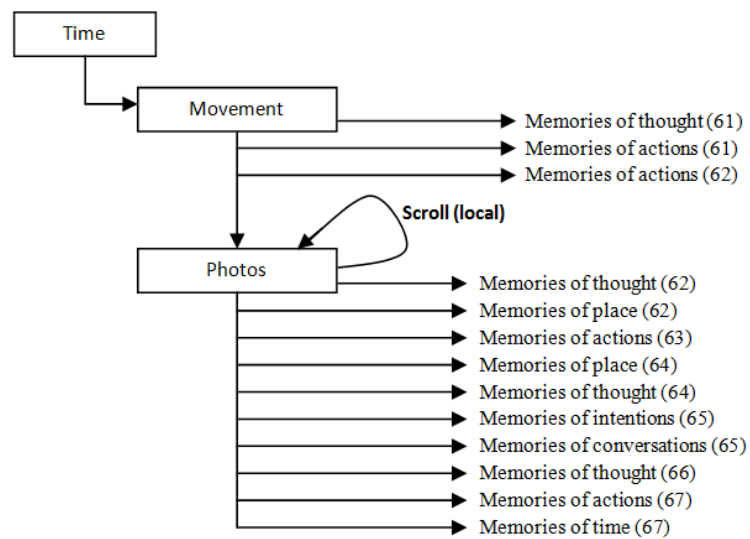
[25] "... those photos captured in London" ... [25] "... that is Victoria station" ... [26] "... the bus arrived exactly on time" ... [27] "... there we were walking out of the station" ... [30] "... we crossed the road without any attention" ... [32] "... it was another alternative short routes to our destination" ... [33] "... it was a sunny day and the sky was clear" ... [33] "... these photos here captured in the Hyde park" ... [35] "...my friend shows me olive tree" ... [36] "... it was big surprise for me" ... [37] "... I could not believe my eyes, Olive tree in London" ... [37] "... there, we had our breakfast" [38] "... some food appears in the photos ... I can remember the taste of some" ... [39] "... the tea was too cold" ... [40] "... we spent a long time having the breakfast" [40] "... we did not sit on the chairs they were wet" ... [41] "... some people were swimming in the river".



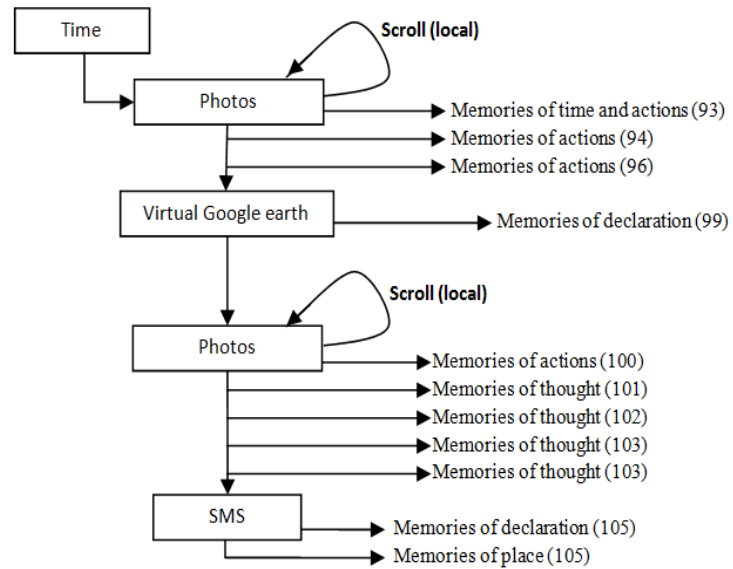
[51] "... those photos there captured in the Hyde Park" ... [51] "...I was sitting" ... [52] "... that phone call to my wife" ... [53] "... there, my friend joined me" ... [54] "... we sat in the opposite side of the park" ... [54] "... people in the Hyde Park were enjoy different activities" ... [56] ... there, we had our lunch".



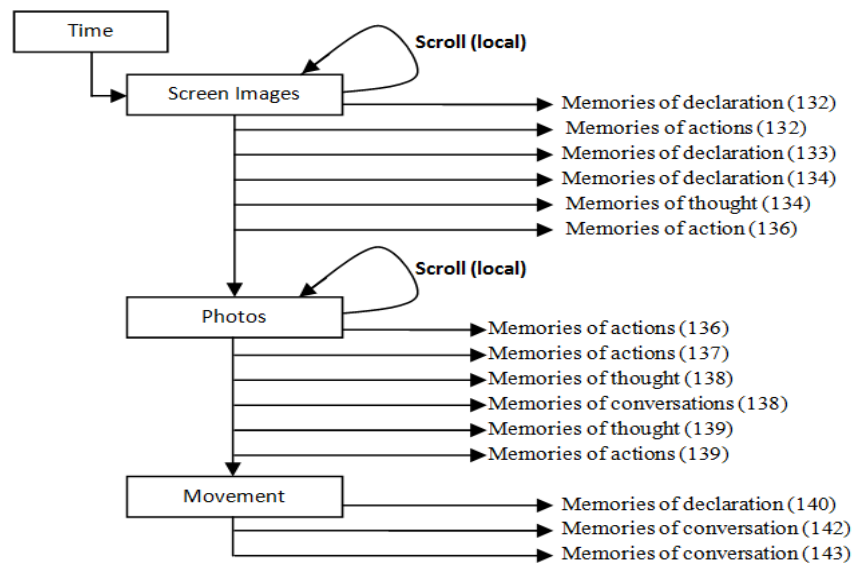
[61] "... the weather was very nice" ... [61] "... we decided to walk" ... [62] "... we stopped there" ... [62] "... I was looking at big Gazelle Statue" ... [62] "... there, we were in shop" ... [63] "... we bought some food" ... [64] "... those photos were taken at Victoria bus station" ... [64] "... we arrived just 15 minutes before the departure time" ... [65] "... we were on our way to the bus" ... [65] "... that woman there asked me to check before her" ... [66] "...they were a group and she likes to sit together" ... [67] "... that is the driver was checking my ticket" ... [67] "...the bus start moving just three minutes after the departure time".



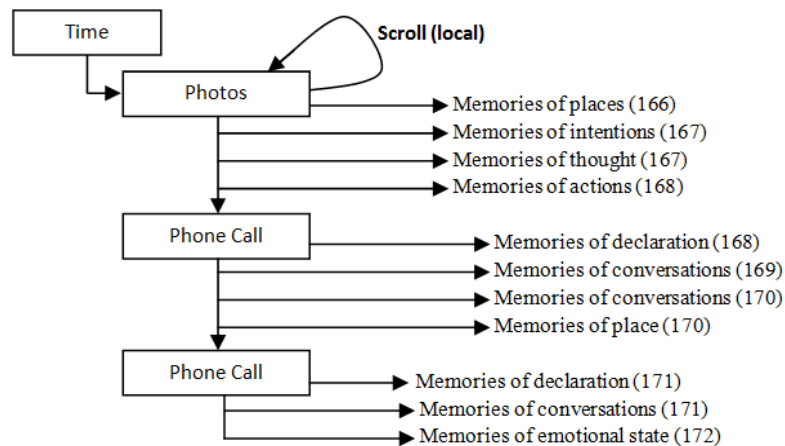
[93] "... there, I had my breakfast with my wife" ... [94] "... I did not take the children to the school my wife did that instead of me" ... [96] "... I was in the main street waiting for the bus" [99] "... that is my path on the Virtual Google earth" ... [100] "... I gave the delivery card to the postman" [100] "... Here, I was checking the deilivery Box" ... [101] "... I had an appointment with the engineer" ... [102] "... he gave me an open time from" ... [103] "... he did not come at that day" ... [103] "... before the time due I received SMS from the company ... they changed the appointment to the next day" ... [105] "... that is the SMS I received" ... [105] "... I was in the shop".



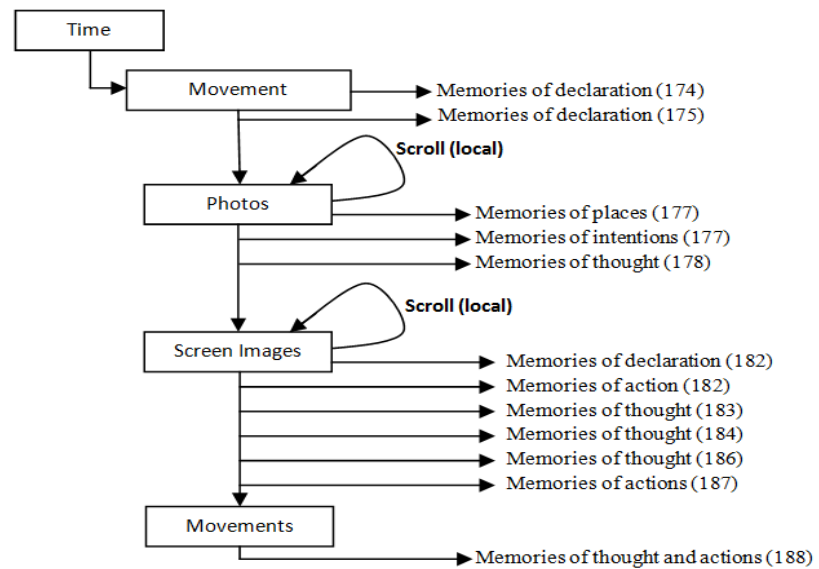
[132] "... I was working on the computer" ... [132] "... I was checking may email Inbox" ... [133] "... that email is from my son School" ... [134] "... the other one is from Scholar Alert, it includes two new papers , one of them is related to my work" ... [136] "... I spent a long time reading it" ... [136] "... those photos here showing me watching my son working on the computer" ... [137] "... he was playing some games" ... [138] "... the game was very hard and each time he was calling me for help" ... [138] "... I asked him to watch cartoon DVD's instead of playing that game" ... [139] "... he did that" ... [139] "...but, when I moved he turn back to the same game" ... [140] "... my wife was preparing some tea, I can see the kettle movement there .. the washing machine was working" ... [142] "... my wife told me about her sister graduation and the graduation party" ... [143] "... she said, she received a phone call from her brother" .



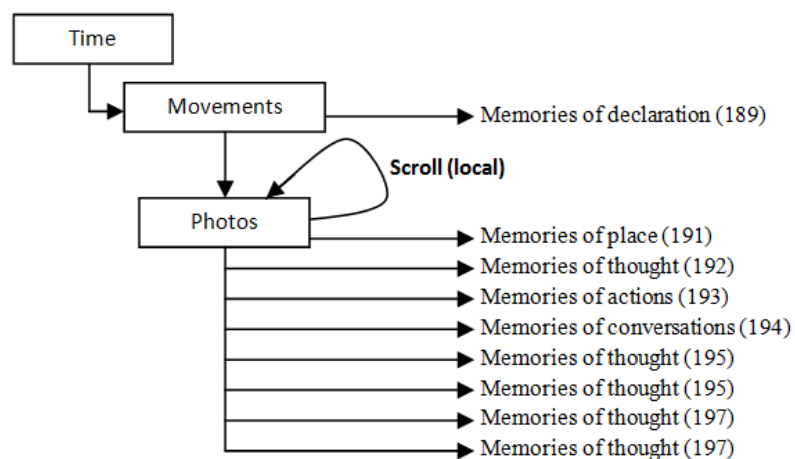
[166] "... there, I was in the electronic shop" ... [166] "... I was searching for a phone cable" ... [167] "... I found many in that shop, but not what I was looking for" ... [168] "... I bought one form the next shop" ... [168] "... that phone call was from my wife" ... [169] ...she asked me about the kids trip letter" ... [170] "... I asked her to make me remember it next day" ... [170] "... there, I was in the high street" ... [171] "... that phone call was from my uncle" ... [171] "... he told me his son is still sick" ... [172] "... I was very sad to hear that".



[174] "... that graph shows my body and hand movements" ... [175] "...I was walking and then stopped" ... [177] "... those photos taken at the Vodafone shop" ... [177] "... I was there to buy top up voucher" ... [178] "... the shop was empty and retailers were talking together" ... [182] "... those screen images show I was working on the computer" ... [182] "... I was checking my email" [183] "... that email I recieved from one old friend ...he was asking about how to apply for academic admission for his brother" ... [184] "... he wrote his brother's English is not very well and he needs to take at least one English language course before start his academic study" ... [186] "... I replied him at night" ... [187] "... these screen images shows I was working on one document of my thesis" ... [188] "... I was very busy, I did not move from my chair for more than two hours".

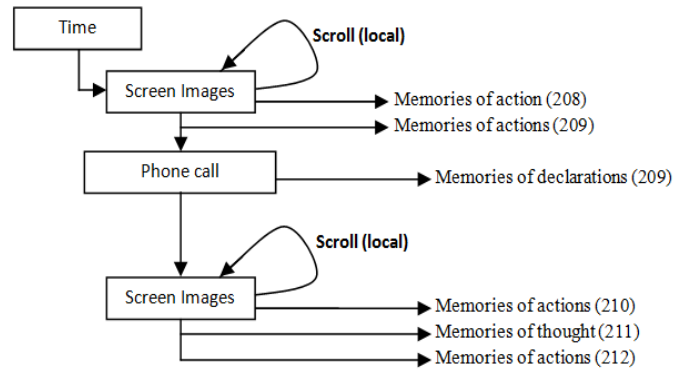


[189] “... tHere, I am stop moving” ... [191] “... those photos there show one big room full of students” ... [192] “... It’s the visa workshop” ... [193] “... I switched off the camera when the speaker start talking” ... [194] “... she said, do not use any media to record the workshop” ... [195] “... it was Chinese girl with the speaker” ... [195] “... the Chinese girl works as interpreter to explain some points for the Chines students “ [197] “...the talk was divided into two parts ... the first part given by a woman and the second one was given by a man” ... [197] “... at the end of the talk checklist was distributed for the attendance to be eligible to make their appointments.

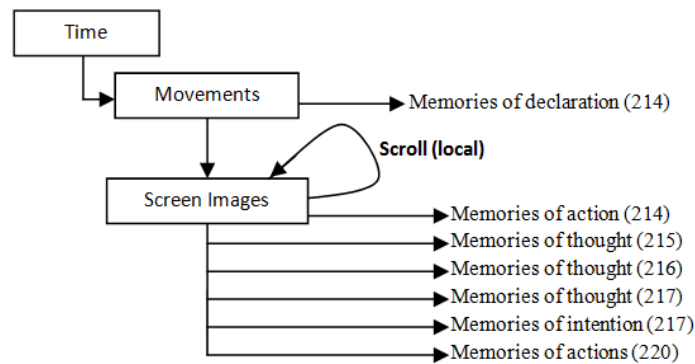


[208] “... there, I was serving the internet, I was searching for the latest news” ... [209] “... those screen images show I was reading a paper” ... [209] “... that phone call I received from my wife” ... [210] “... there, I was

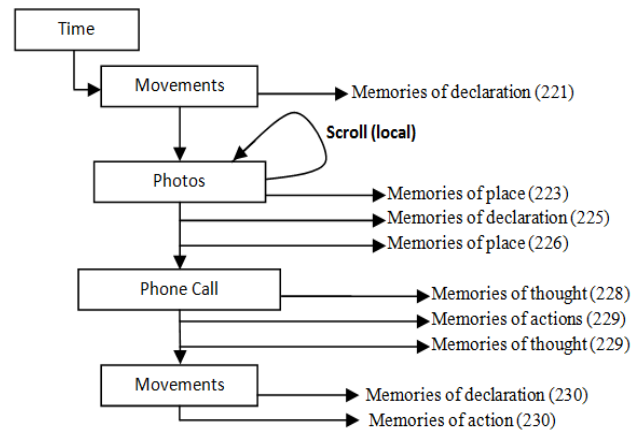
writing” ... [211] “... I worked many times on that chapter” ... [212] “... I started from the beginning”.



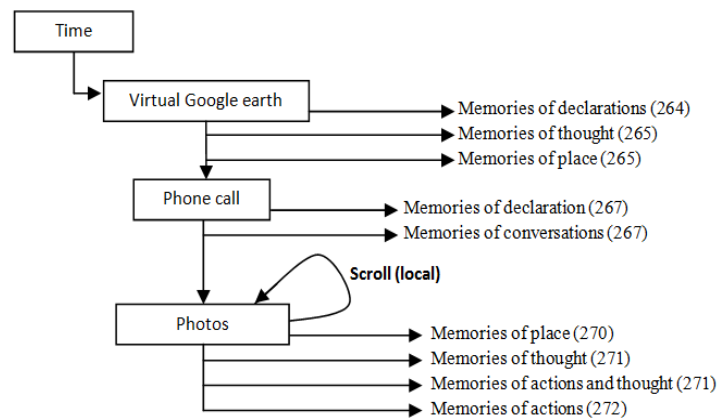
[214] “... here, the movement stopped and the photos started again” ... [214] “... those screen images show I was testing the observation software” ... [216] “... the movement of the participants was not clear enough to follow” ... [217] “... in the last meeting my supervisor recommended to make it little bigger” ... [217] “...here, I was looking for some document that I need to renew my Visa” ... [220] “... here, I back again to the software”.



[221] “... no movements in the first 15 minutes, but after that I can see significant movement” ... [223] “... the second photo shows I was in the high street” ... [225] “... I left the lab at 07:14 pm, it was not dark and the sky was clear” ... [226] “... there, I was in the pharmacy” ... [228] “... my son has got a high temperature” ... [229] “... there, I was checking out” ... [229] “... at night his temperature rises again” ... [230] “... here, no movement of my hand and body, I stopped for awhile [230] “... I was withdraw some money from the cash machine”.

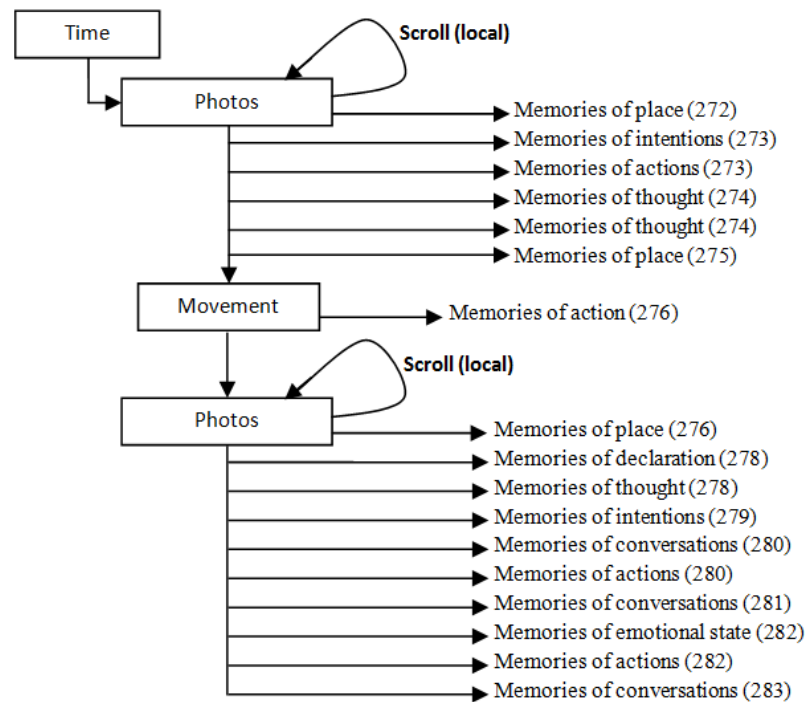


[264] “... no path and no photos on the virtual Google earth” ... [265] “...It was cloudy day” ... [265] “... I got the signal when I stop at the bus station” ... [267] “... that phone call was to my wife” ... [267]... I told her about my doughter picture” ... [269] “... those photo taken in the bus” ... [270] “... the street was empty and there were only few cars on the road” ... [271] “... the driver was little bit fast” ... [271] “... at traffic light, he hits the car in front of him” ... [272] “... the driver of the other car did not stop and did not talk to the bus driver” .



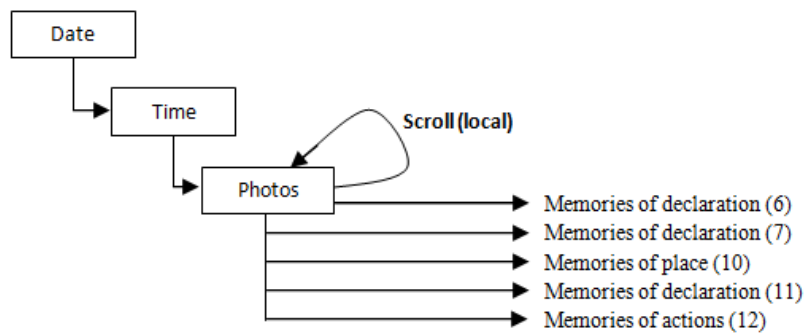
[272] ... there, I was in the shop” ... [273] “... I was searching for an extension for my landline phone” ... [273] “... that photo shows I was checking out.” ... [274] “... I changed it in the next day” ... [274] “... it’s plug-in was different” ... [275] “... those photos there shows the high street” ... [276] “... I was walking ... I stopped there” ... [276] “... when I checked the photos of that time I found many of them show the Haymarket metro station” ... [278] “... those photos show one friend face ... he was talking to

me” ... [278] “... I saw him when he was withdraw some money from the cash machine” ... [279] “... I stopped there to have chat with him” [280] “... few weeks ago he told me about renewing his visa” ... [280] “... when he comes out, he found me waiting for him” ... [281] 2... he asked me about who I am waiting for” [282] “...he laughed when I told him I was waiting for him” ... [282] “... we walked together to the culture lab front door” [283] “... he told me, he want to be in London next week to renew his wife passport”.

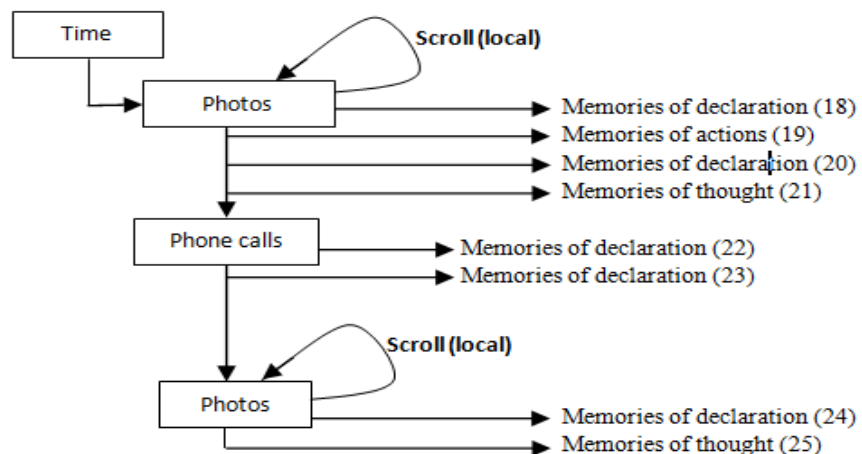


Appendix R11

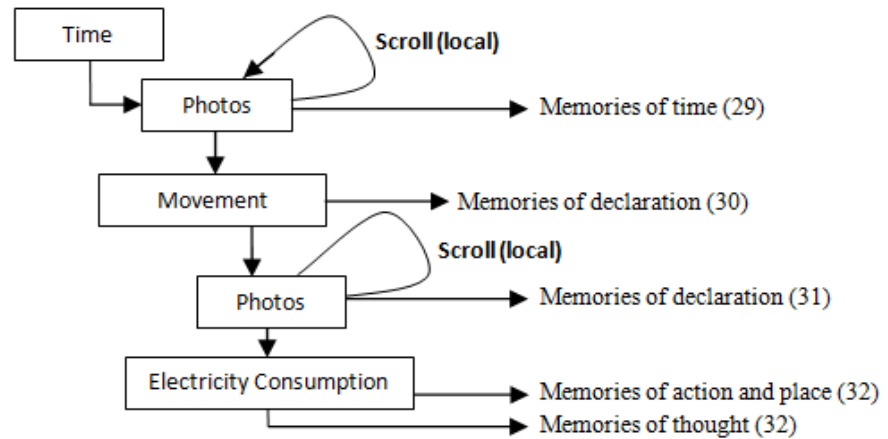
[6] "... the first photos graph is appearing at 10 O'clock pane and the last one appears in 20 O'clock" ... [7] "... I can see no gaps between them, but I can see that the amount of the photos are not equal" ... [10] "... I am at home ... the four photos were taken at home" ... [11] "... I can see the children in the third and the fourth one no school at that day" ... [12] "... I was sitting on the sofa" ... [12] "... I can see no movement of my body and just a few movements of my hand for a short time"



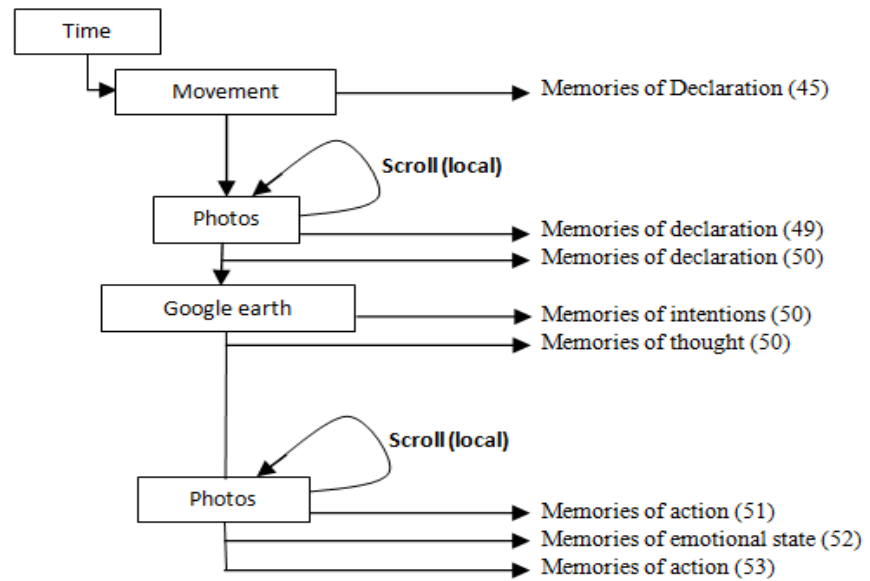
[18] "... the first photo was taken at 10:24 it shows the TV screen"... [19] "... the next photo shows I was watching cooking show on the TV... the whole photos there show that TV's screen" ... [20] "... I spent a long time watching TV" ... [21] "... I tried to cook that food times, but it does not come as shown in the TV" ... [22] "... I missed two phone calls from my sister" [23] "... the two missing calls appear there " ... [24] "... those photos show the children were playing video games" ... [25] "... sometime they refuse to share their games".



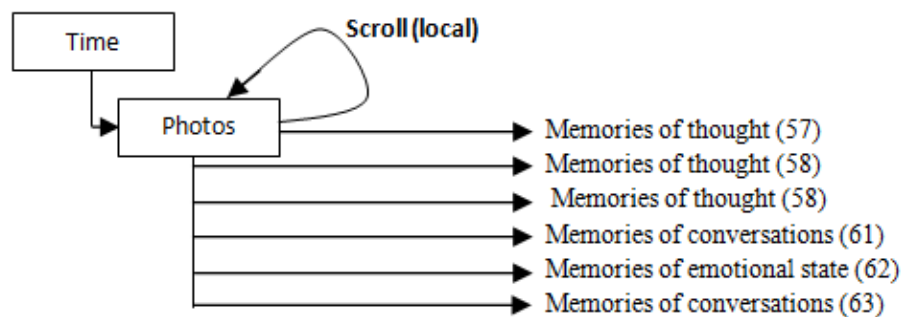
[29] "... we had a lunch at 12:20 ... that photo shows I was holding some plates" ... [30] "... and that one shows the fridge door was open, I can see the fridge movements there as well" ... [31] "... those photos here show the children in front of me having their food" ... [32] "... I left the TV Woking while I was in the kitchen" ... [32] "... nobody was watching the TV".



[45] "... the first photo of that hour's pane taken at home, and the others were taken outside in the street" ... [49] "... we went out exactly at 15:09 ... this photo shows the front door" ... [50] "... on the virtual Google earth I can see my path there" ... [50] "... we went to the park" [50] ...the children asked me to take them to play out in the park" ... [51] "... those photos show the children were playing by swings" ... [52] "... they were too happy" ... [53] "... I was standing there watching the kids".

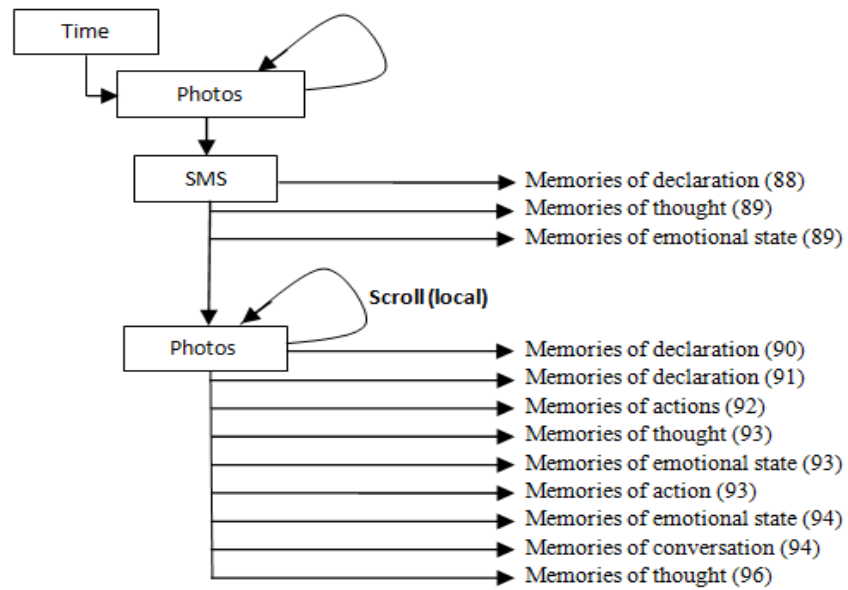


[57] "... I meet one of my previous English courses mate in the park" [58] "... I have not seen her for long time" ... [58] "... she was there with her daughter" ... [61] "... she told me about her divorce and how her husband left the house" ... [62] "... I was very sad to hear that... she made me cry" ... [63] "... she told me she is looking for a job".

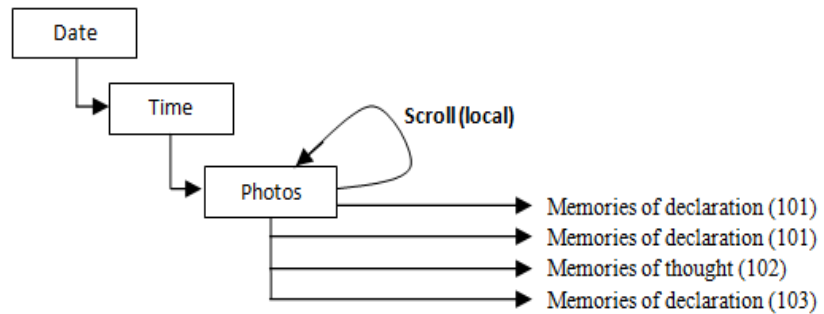


[88] "... that SMS I received from my sister" ... [89] "... I did not expect her to remember my daughter birthday" [89] "... It was a big surprised for me" ... [90] "...that photo shows the candles lights and some cake ..." [91] "... we did a small birthday party" ... [91] "...those dark photos taken when we switch off the light" ... [92] "...the children started singing after they turned off the light" ... [93] "... their voices were loud little bit" [93] "... but it was a wonderful and amazing time" ... [93] "...they repeated the song many times" ... [94] "... they were very happy and excited " ... [94] "... my

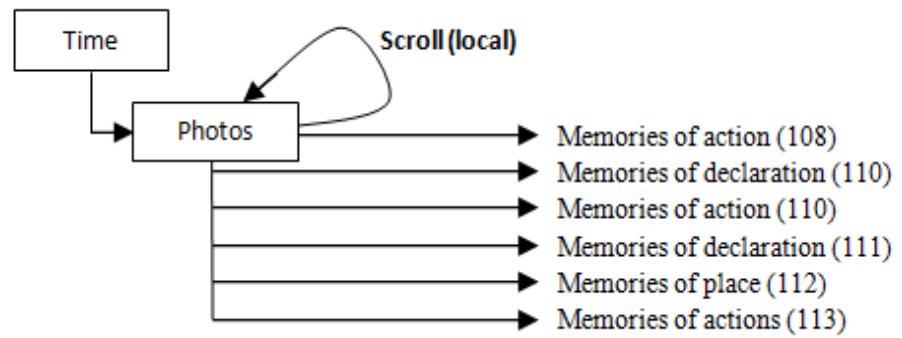
daughter said the cake need more cream, but it is delicious“ ... [96] ...I did not see any SMS sent to my sister, but I sent an email.



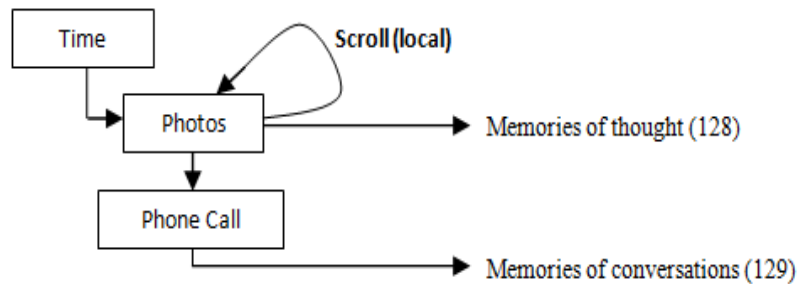
[101] “... I wear the camera at 10 O’clock morning” ... [101] “... it did not capture as much as 12 O’clock” ... [102] “... I did pause the camera many times” [103] “... no photos at 18 O’clock”.



[108] “... they were watching cartoons on the TV” ... [109] ... the girl was sitting on the edge of the sofa, and the boy was play by his new toys” ... [110] “... I was drinking my coffee” ... [112] “... those photos show the kitchen [113] “... I was preparing some food for the kids”

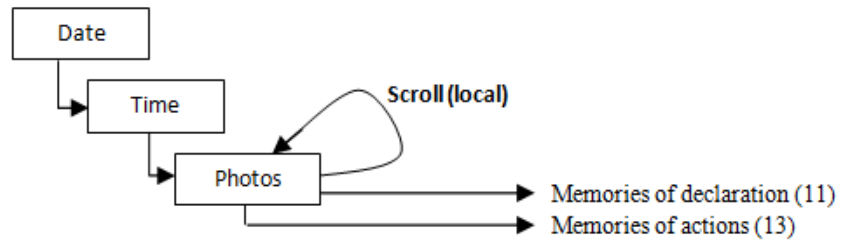


[128] "... I think, we have quests that day ... these photos show my friend with her Mum" ... [129] "... my friend called me that morning and told her Mum would like to visit me".

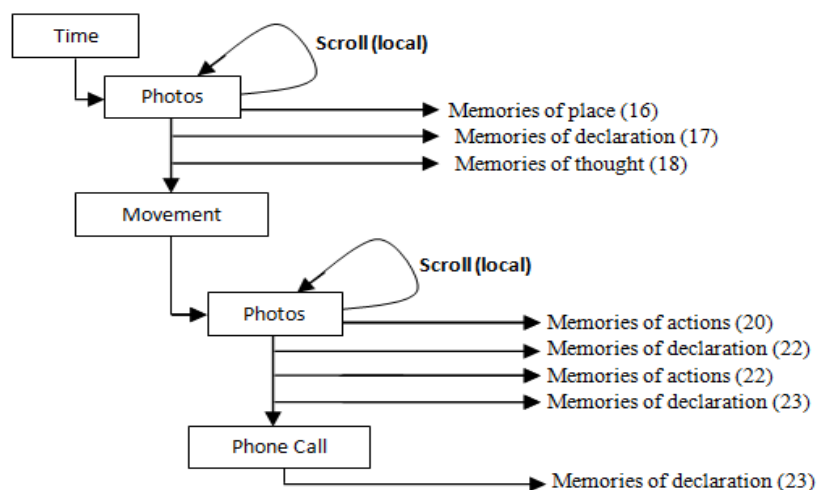


Appendix R12

[11] “... the first photo I capture was at 10 am morning and the last one was captured at 8 pm evening ... I can see the photos graphic lines in some hour’s pane are quite short!” ... [13] “... I switched off the camera many times during that day”.

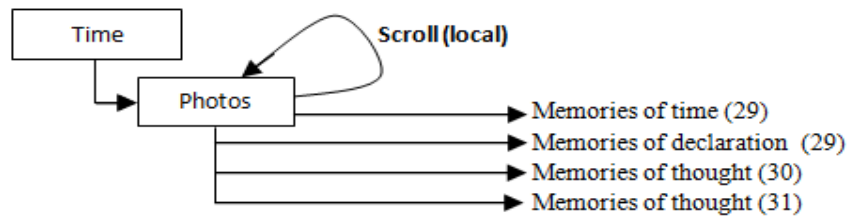


[16] “... the whole photos were taken at home” ... [17] “... as I can see there the children appear in the third and fourth ones” ... [18] “... the school does not start yet ... I can see there, at the first quarter of the hour it was no movement of my body and only just a few movements of my hand” ... [20] “... I was watching the TV and the children were playing next to me” ... [22] “... the first photo captured exactly at 10:24” ... [23] “... those photos show it was a cooking show on the TV” ... [23] “... I missed two phone calls at that morning”.

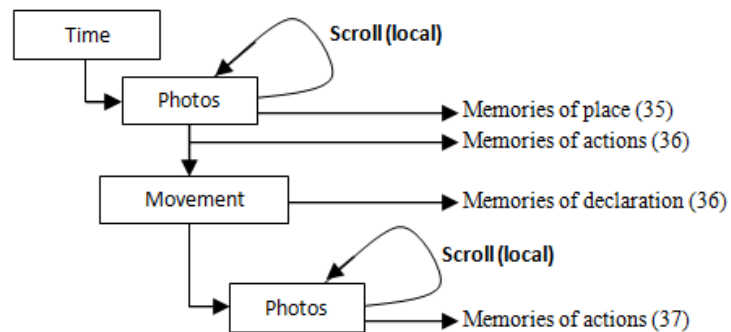


[29] “... those photos show the lunch time” ... [29] “... my daughter was sitting next to me ... my son was in sitting in front of me [30] “... they did

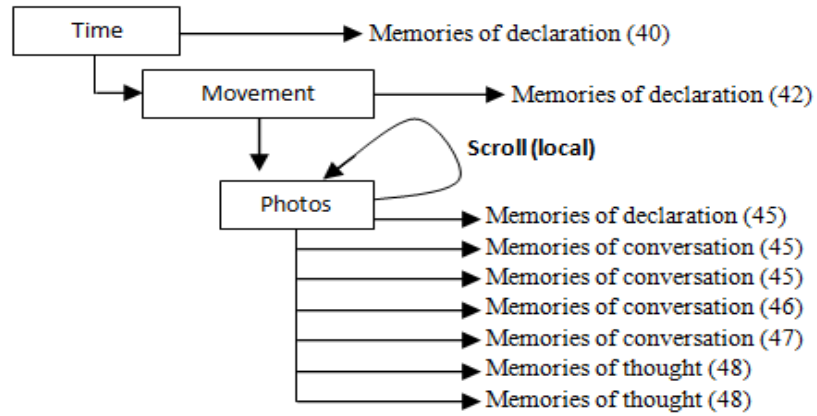
not stop talking while they were eating their food” ... [31] “... she does not eat anything”.



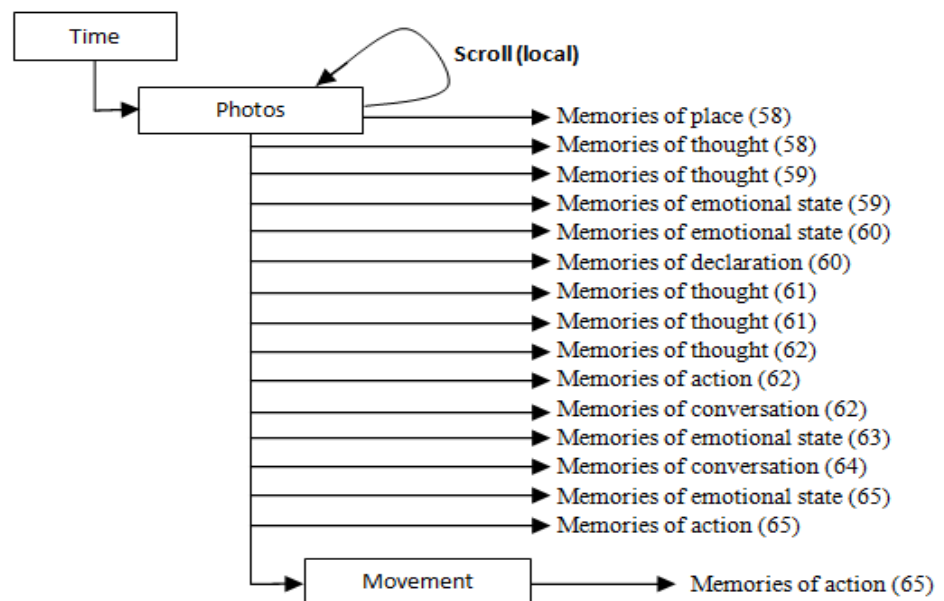
[35] “... I am still in the kitchen” ... [36] “... I was washing the dishes” ...
 [36] “... at that time the washing machine was working” ... [37] “... that photo shows I was talking to my son ... he does not share his sister the play station games” .



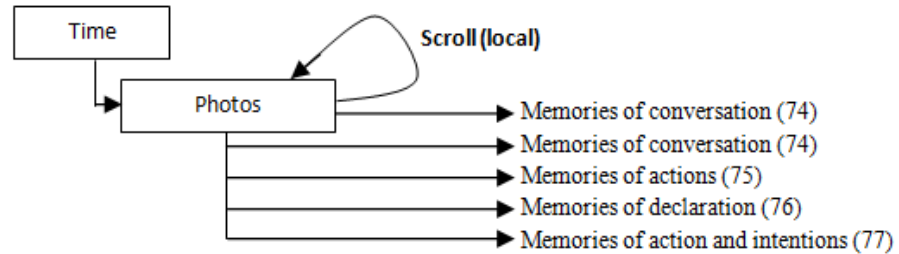
[40] ”... I can see there both the three and four O’clock panes appear with different background colour” ... [42] “... that is my hand movements and that is the movements of the front door” ... [45] “... those photos show one of my neighbour talking to me” ... [45] “... he told me about the noise that happened at the downstairs flat” [46] “... he said, it was fighting between the girl and her boyfriend” ... [47] “... he said they did not stop until the police came and take them to the police station ... they are disappear [48] ... I did not see them again [48] “... their flat still empty”,



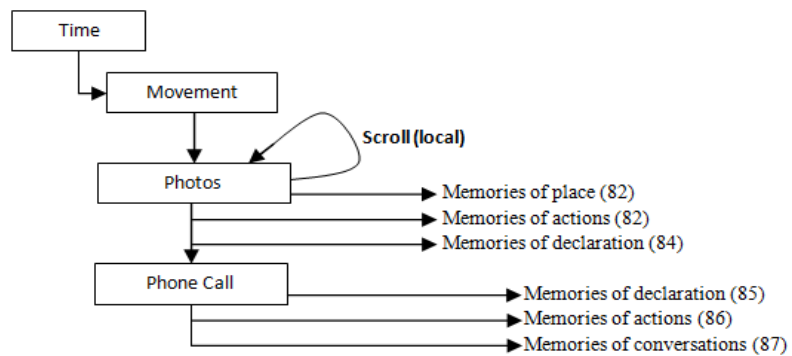
[58] "...there were two girls playing in the park" ... [58] "... One of them studying at the same school of my children" ... [59] "... I saw her with her mum many times" ... [59] "...her mum is friendly woman" ... [60] "... she is always smiling and greeting people" ... [60] "... those photos show one of my classmate" ... [61] "... we had an English course together one year ago" ... [62] "... I have not seen her for a long time" ... [62] "... I had chat with her" ... [62] "... she told me about her divorce" ... [63] "... I felt very sad for her and to hear that bad news ... she laughed when I said I am very sorry to hear that" ... [64] "...she said it was her decision and she is very happy of that" ... [65] "...it was very strange for me to hear that, but I laughed as well" ... [65] "... She left when the children start asking me to take them to the library.



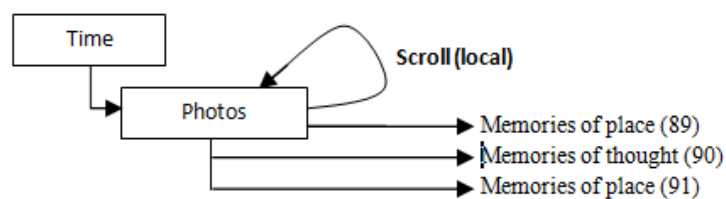
[74] “... they asked me to borrow that book” [74] “... my daughter said that book similar to the one she saw in the school” ... [75] “... my son changed his mind when he found a new book” ... [76] “... we spent a quite long time in the library” ... [77] “... we went out to buy some stuff for the birthday party”.



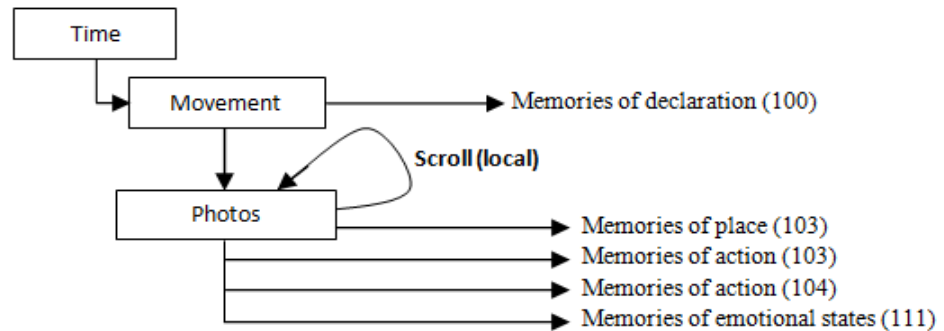
[82] “... we are in the shop” ... [82] “... we bought many things for the party” [84] “... those photos show trolley and some of what we bought” ... [85] “... that phone call I received from my friend [86] “... she called me when I was checking out” ... [86] “... she asked me about my city news [87] “... she said there is a good news in TV, I told her I am with the kids in the shop”.



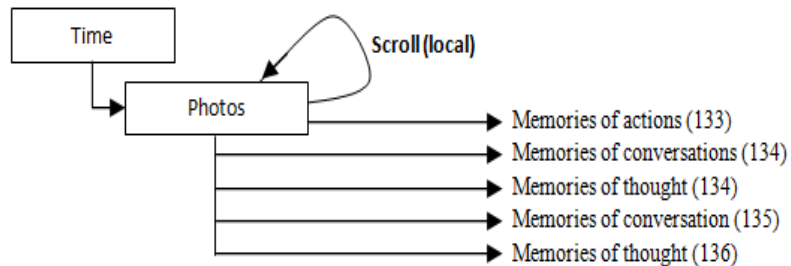
[89] “... that is the bus stop” ... [90] “... that woman asked me a question, but I could not understand her accent”. ... [91] “... those photos taken in the bus”.



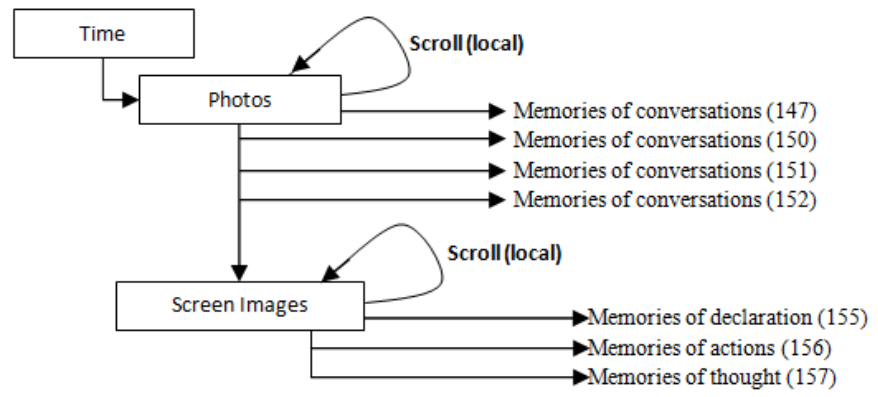
[100]”... there, I can see long movements of my hand, also I can see the movements of the fridge and the cooker as well” ... [103] “... all of these photos taken at the kitchen” ... [103] “... I was preparing some cake for the party” ... [104] ”... I cooked many things at the same time”... [111] “... they enjoyed the party very much”



[133] “... those photos show me holding a book” ... [134] “... my son asked me to read it for him” ... [134] ”... he tried to read it by himself, but he could not” ... [135] “... his teacher said he made a good progress, but he still needs more help and encouragement at home” ... [136] “... that book still at home, we forget to bring it back to the library...”.

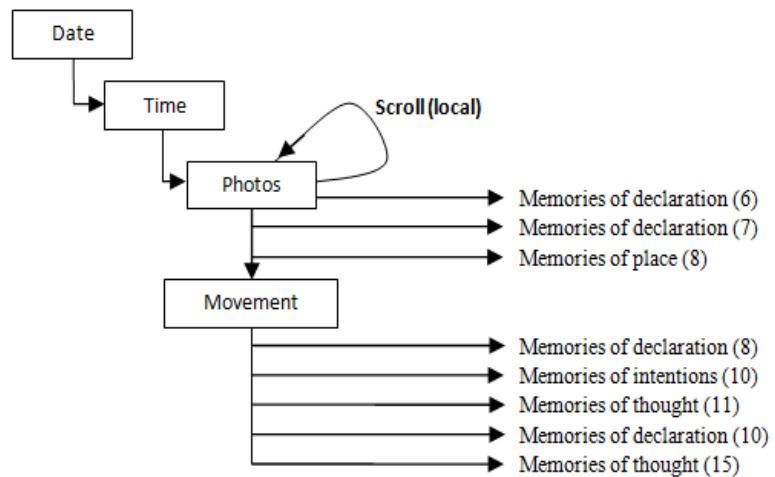


[147] “... my friend’s Mum talked about her daughter childhood” ... [150] “... she said, she was very active and love playing with other girls” ... [151] “... she mentioned, the first year of her study she did not like the school, she refused to go to the school” ... [152] “... she cited, she only enjoyed the school when she grew up” ... “[155] “... the kids spend plenty time playing games on the computer” [156] “... they played different games and they watched Cebeebes channel” ... [157] “... they were nice and a quiet”.

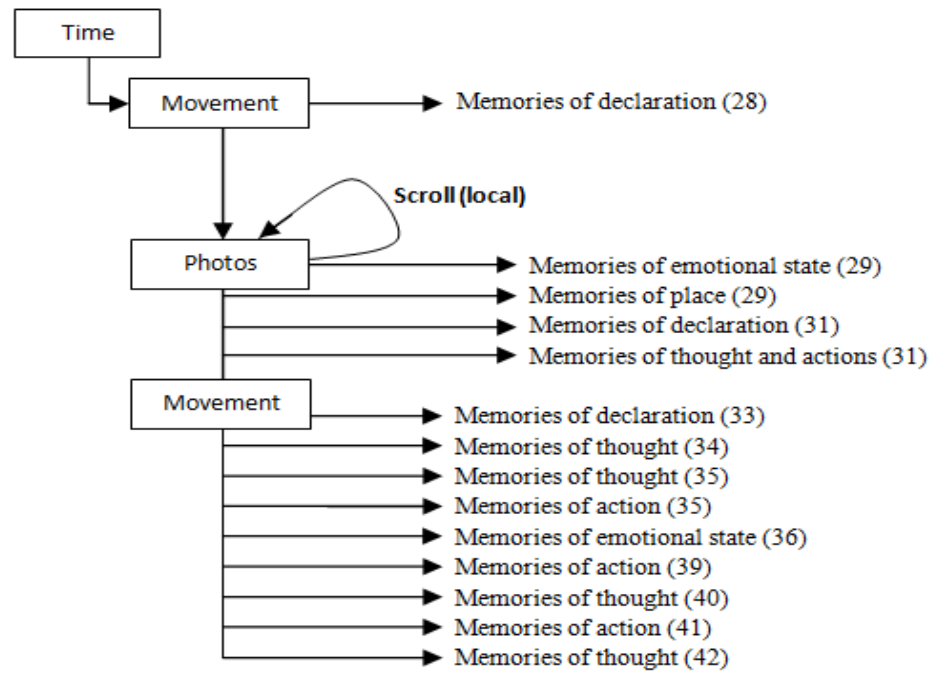


Appendix R21

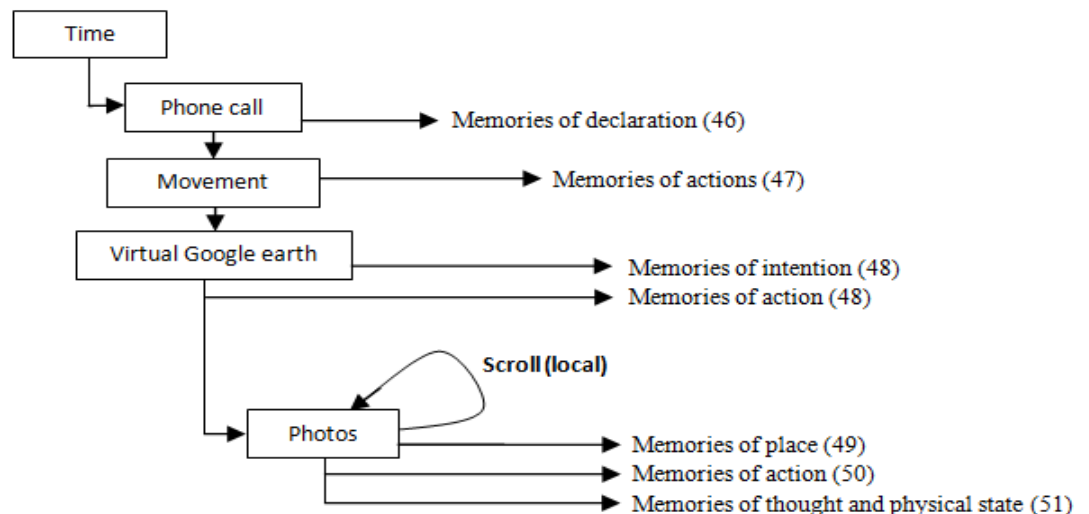
[6] "... I started capture the photos at 08:00 O'clock" ... [7] "... the first photos was captured at 08:47 am" ... [8] "... I was in the kitchen" ... [8] "... here, I can see the movements of the kettle, toaster, and the fridge" ... [10] "... I was preparing the breakfast" ... [10] "... I cannot see any of the children food or cups on the table" ... [15] "... the school does not start yet".



[28] "... that is the front door movements" ... [29] "... those photos here showing how happy they were" [29] "... we are in the front of the library" ... [31] "... those two photos captured inside the library" ... [31] "... I switched off the camera and kept it in my bag" ... [33] "... I did not stop moving ... I was following the kids" ... [34] "... I saw many parents who I knew"... [35] "... we did not spend a long time there" ... [35] "... we just left after we borrowed some books" ... [36] "... the children were very happy they found all books they were looking for" ... [39] "... we went to the park" ... [40] "... I forget to wear the camera and turn it on again when we went out of the library" ... [42] "... two teenage girls were there ... they talked and played with my daughter".

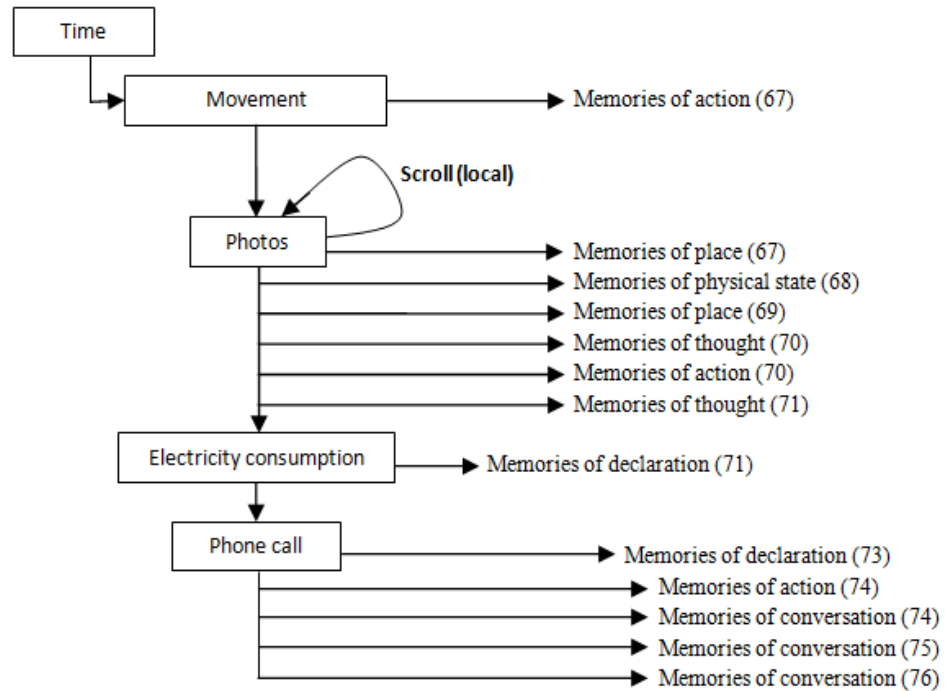


[46] "... that is my sister phone call " ... [47] "... I moved after that phone call" ... [48] "... our destination is Gateshead Centre"... [48] "... I take the children to the shop to buy some shoes" ... [49] "... those photos taken in the shop" ... [50] "... that photo shows the one we bought" ... [51] "... it was not comfortable it is high heel".

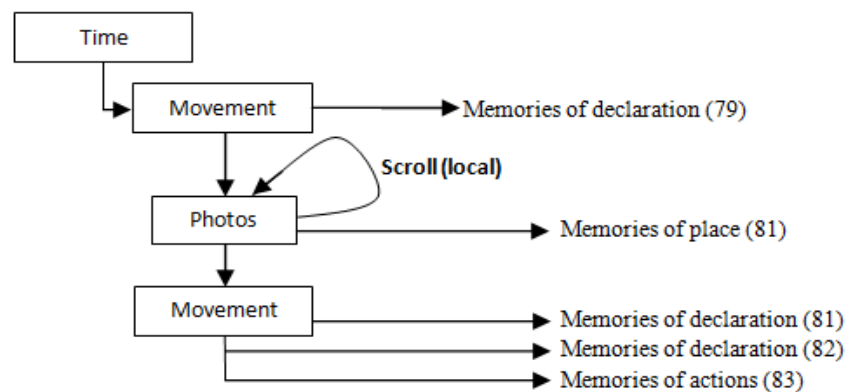


[67] "... I was walking there" ... [67] "...there, we are in the bus stop ... [68] "...I felt very tired and the children as well" [69] "... we are in the bus" ... [70] "... they slept immediately after we arrived" ...[71] "... they did not change their dress" ...[71] "... I truned on the TV ... no movement, and the

TV screen appeared in many photos” [73] “... that phone call was from my friend” ... [74] “...we had a short chat” ...[74] “... I asked her about her new baby born” ... [75] “... she said her new baby sleep during the day and wake up at night” ... [76] “... she told me her sister who living in the other city will visit here next week...”.

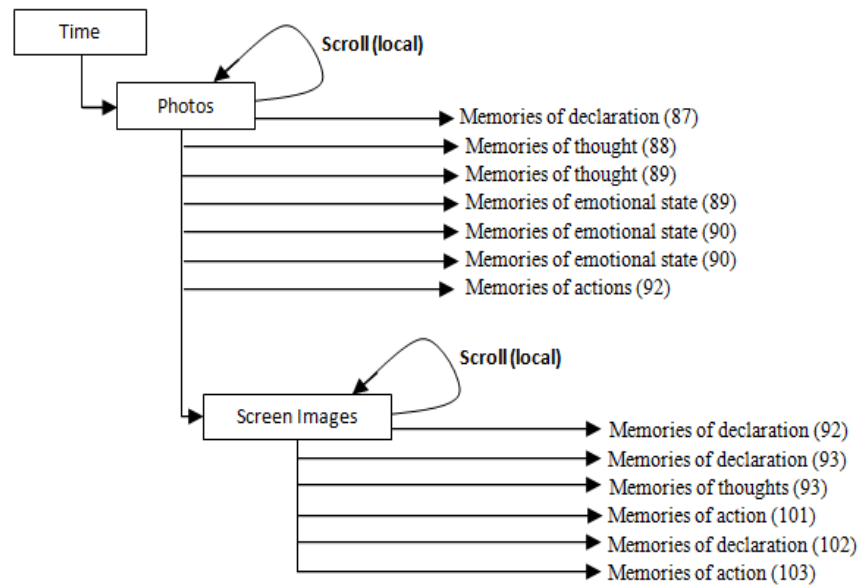


[79] “... here, I can see significant movement of both body and hand” ...
 [81] ... there, I was in the kitchen” ... [81] “... that is the kettle and the fridge movements” [82] “... that photo shows the kettle and the next one shows the fridge door” ... [83] “... I made a coffee ... those photos there show me back to watch the TV”.

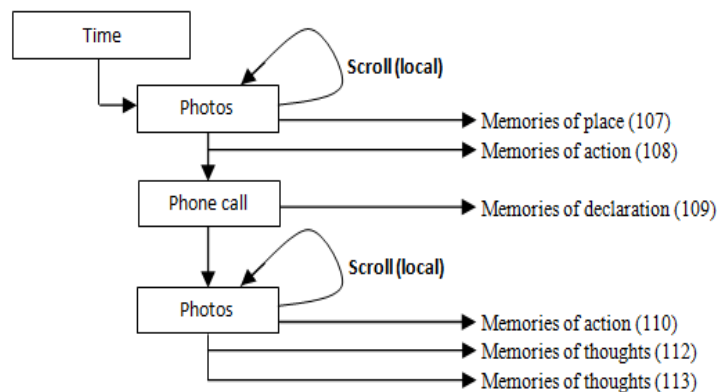


[87] “... I can see some parts of people who presented the news, but I cannot remember what was the news about” ... [88] “... I can remember that famous singer and her beautiful song” ... [89] “...she was singing for her

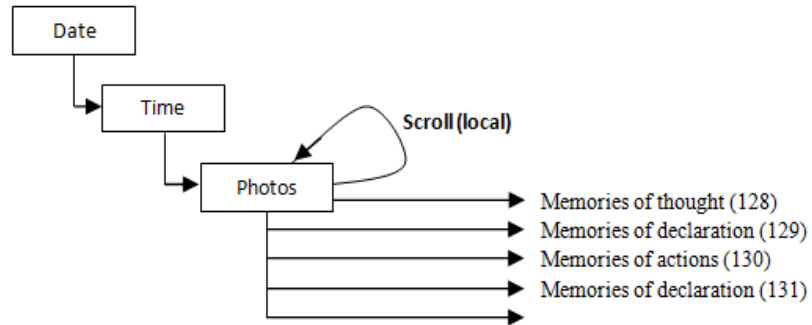
mother ... she has a very nice voice” ... [89] “... it takes me back to my childhood as well” ... [90] “... I felt as living again that moments” ... [90] “... I heard that song many time but, I still have the same filling each time I hear it again” [92] “... I was working on the laptop” ... [92] “... I was serving the web” ... [93] “...that email from my sister” ... [93] ...she sent me some photos” ... [101] “... there, I opened my Facebook account [102] “... I found new photos of my sister and her children” ... [103] “... I wrote some comment about some of her photos”.



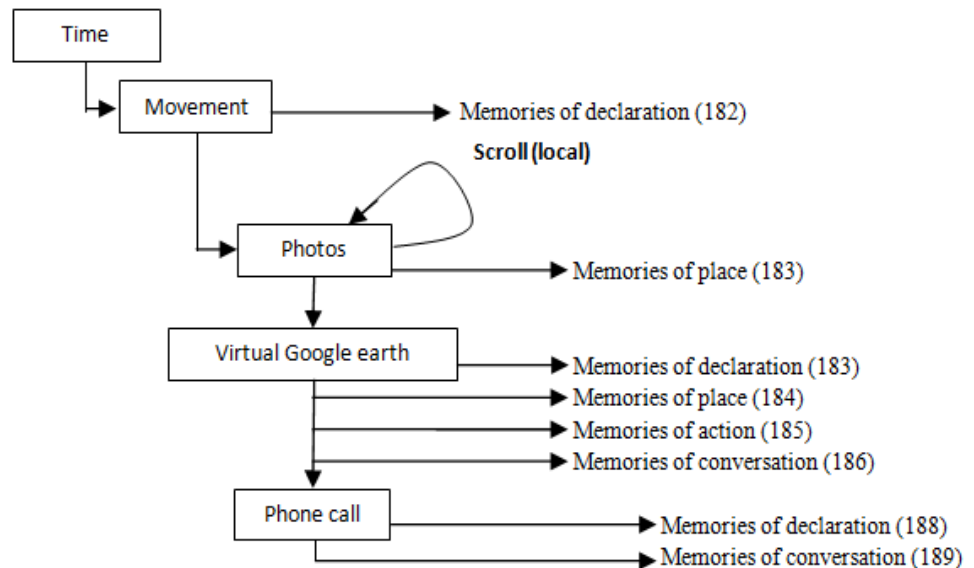
[107] “... I was in the front of the wash machine” ... [108] “... I was doing laundry” ... [109] ... that phone call was from my brother” ... [109] “... I cannot, remember any conversation” ... [110] “... I put the clothes in the machine” ... [112] “... one of the kids changed the washing machine program, it stops working” [113] “... I tried a lot but, it does not work”.



[128] “... during the normal days I wake up early” ... [129] “... I started capture the photos at 08:00 am and I stopped at 09:00“ ... [130] “... I switched off the camera many times, but I cannot remember the reason of that” ... [131] “... I can see the amount of photos I collected at each hour”.

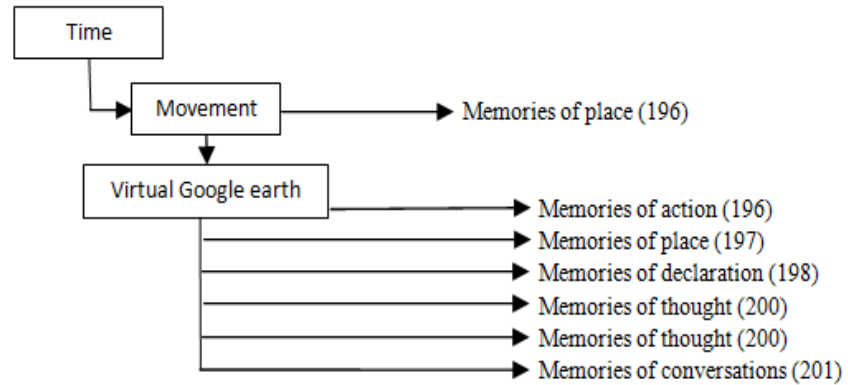


[182] “... there, I was moving” ... [183] “... those photos show the main road” ... [183] ” ... I can see the photos on the virtual Google earth and the path as well” ... [184] “... here, we are at the main entrance of the school” ... [185] “... we sat and look at the kids” ... [186] “... she told me here son sometime did not sleep at night, she said he complained from his stomach” ... [188] “... that phone call I received from my sister” ... [189] “... I told her I am out and I will call here at night” .

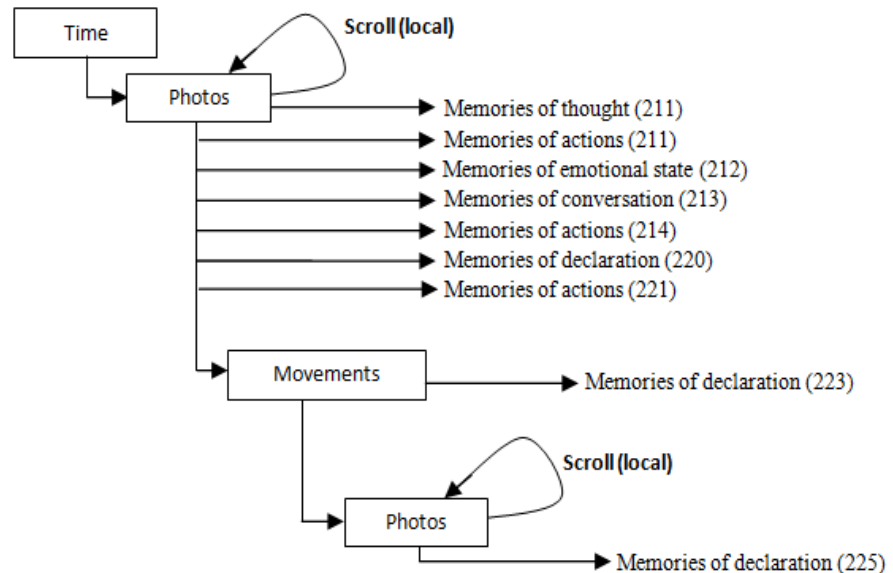


[196] “... that’s the main door of the school” ... [196] “... I did not go directly to house” ... [197] “... we went to the shop” ... [198] ... I am in the shop with the kids” ... [200] “... she went home” ... [200] “... her husband

called her while we are in the school” ... [201] “... she said, one of their family friends invited them to new baby born party”.



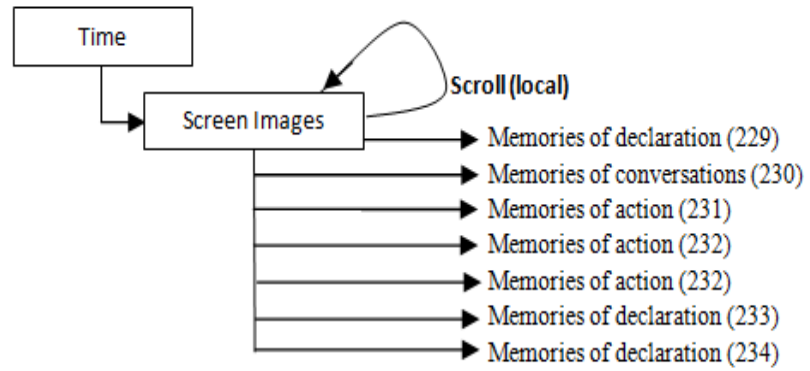
[211] “...not very much, many times they run in the shop” ... [211] “... that photo shows my daughter holding one big teddy bear and asking me to buy it” ... [212] “... she become very sad when I asked her to put it back” ... [213] “... I told her we already had two and we do not need to buy any more” [214] “... this photo shows we check out” ... [220] “...they did not sleep ... they spent all of their time playing” ... [221] “...they played outside in the backyard for long time”... [223] “... here, no movement and all the photos looks the same” ... [225] ... I was watching the TV ... I spent a long time of that”.



[229] “... those images show cartoon movies” ... [230] “... they told me they already watched that video at their school” ... [231] “... they did not stop asking questions about the video” ... [232] “... we watched together until they slept” ... [233] “... there, I checked my email Inbox” ... [234]

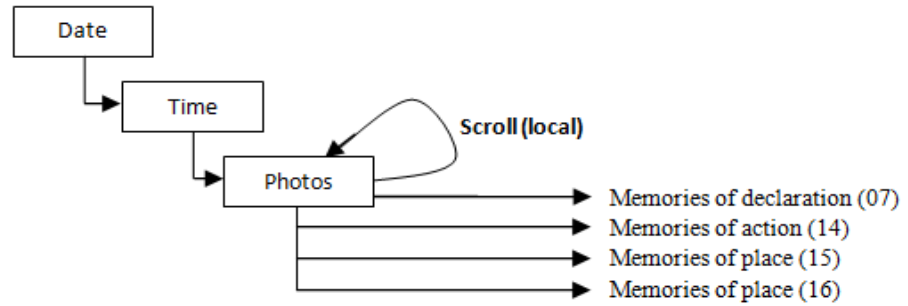
“... that icon shows the details of one email It was from my sister” ... [234]

“... she wrote our aunt is going to married next week”.

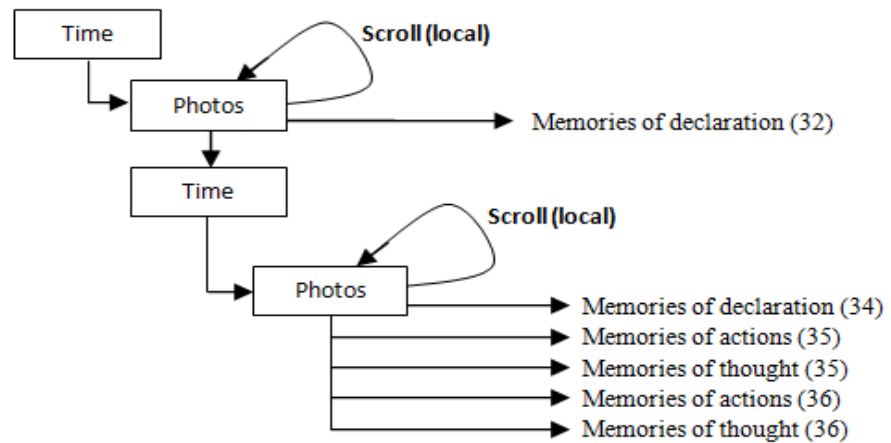


Appendix R22

[07] “...the first photo was taken at 08 am” ... [14] “... I start wearing the camera and capture the photos at 08:45 or later” ... [15] “... the first photo was captured in the kitchen exactly at 08:47 am” ... [16] “... that photo shows the toaster and the next ones shows some food on the table”

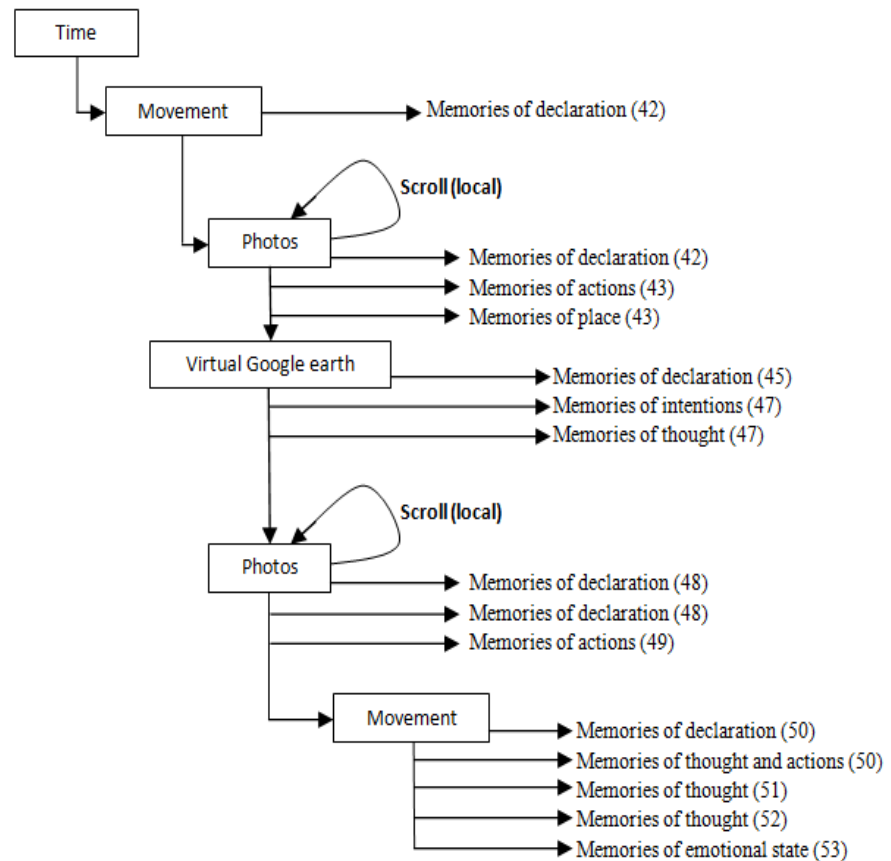


[32] “... nothing was here” ... [34] “... I did not find any breakfast their”... [35] “... they just drunk their hot chocolate with some biscuits” ... [36] “... they refused to eat any food at that morning [36] “... the boy started first and then his sister followed him”.

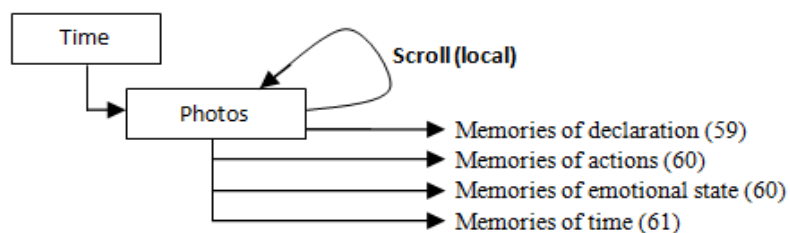


[42] “...that is the front door movements” ... [42] “... those photos show the house downstairs” ... [43] “... the children were dressed up” ... [43] “... that photo shows the front door” ... [45] “... there, I can see the whole path of our walk” ... [47] “...our destination was the library” [47] “...the children asked me to borrow some book story for them” ... [48] “... those three photos there taken inside the library and then no photos” ... [49] “... I switched off the camera and kept it in my bag” ... [50] “... I did not stop

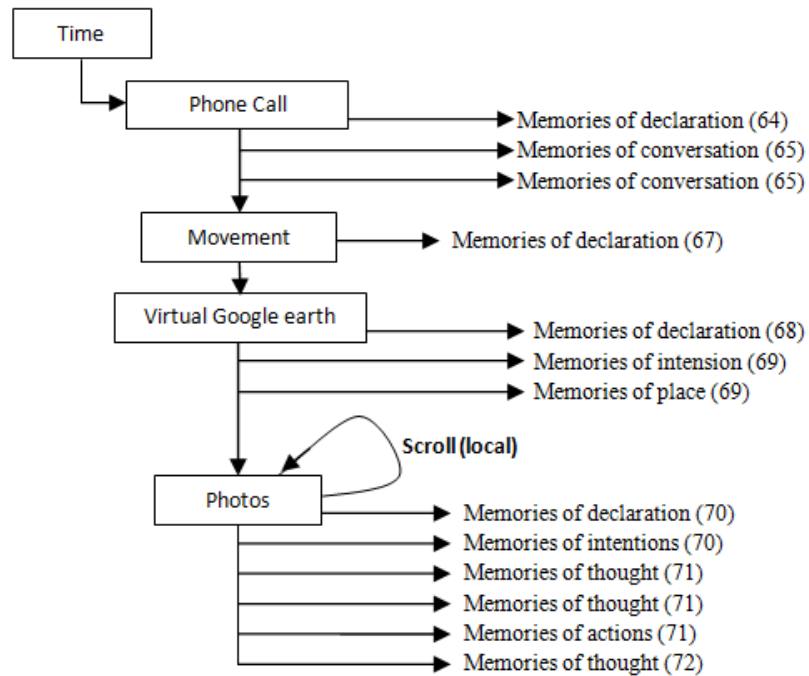
moving” ... [50] “...each time the children were calling me to show me one book” ... [51] “...there were many children there with their parents, but none of them was at the same class of my kids” ... [52] “...we did not spent long time there, we just left after we borrowed the books” ...[53] “... my son was very happy he found the book he looking for”.



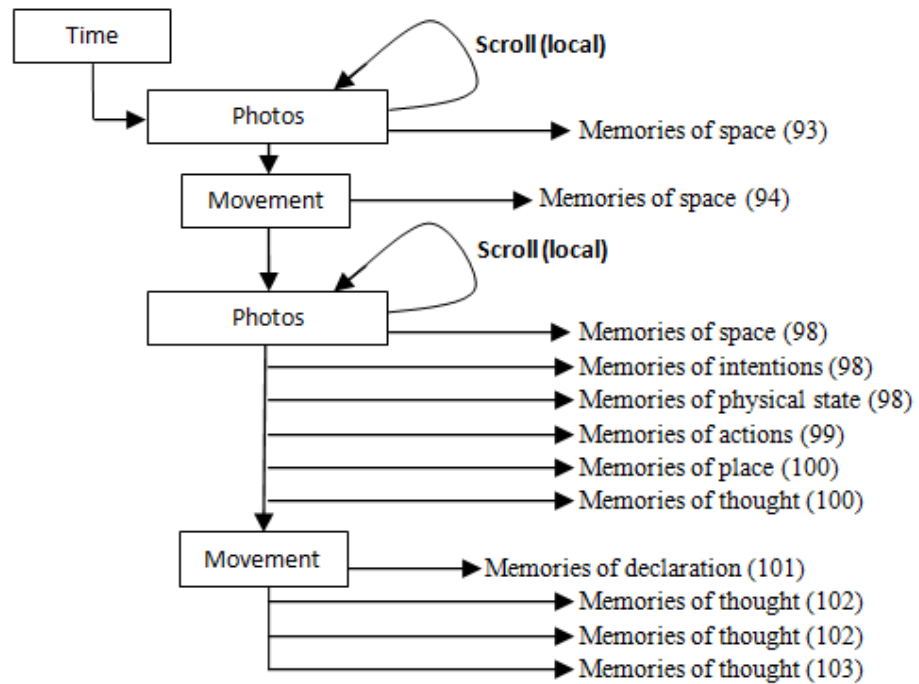
[59] “... here, I switched on the camera” ... [60] “...that photo shows my daughter talking to one girl”... [60] “... although, she always shy, I saw here very confident talking to her” ... [61] “... those photos shows we had our lunch in the park”



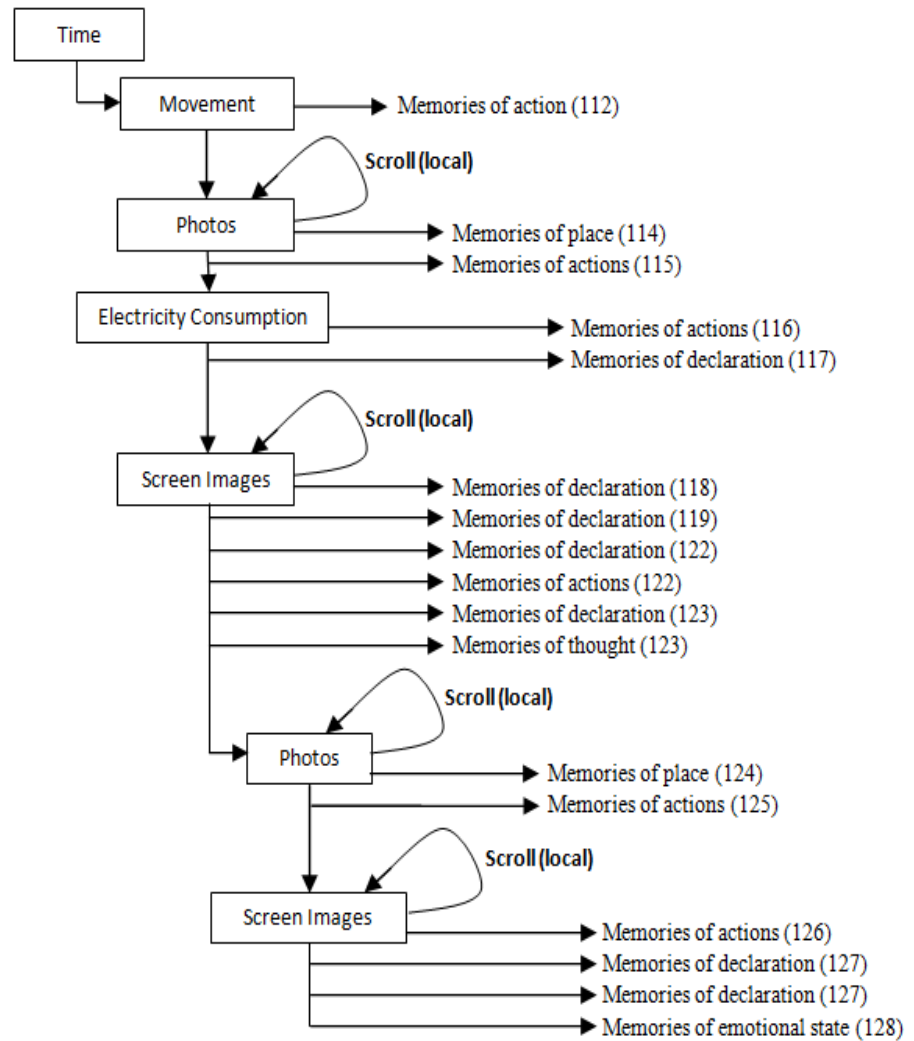
[64] “... I can see that phone call, it was from my brother” ...[65] “...he told me he was sick” ... [65] “...he said he plan to be Abroad next week to do some health tests”...[67] “... there, I can see a long significant movement” ... [68] “...my path on Google earth shows that our destination is the city centre” ... [69] “ ...we went there for some sopping and walk in the city centre [69] “... there, we were in the shop” ... [70] “... this photo shows shoes part” ... [70] “...we were looking for shoes to my son” ... [71] “... we did not buy any for him” ... [71] “... we did not find the one he likes” ... [71] “... that photo shows the one we bought for my daughter, [72] “... she liked it very much”.



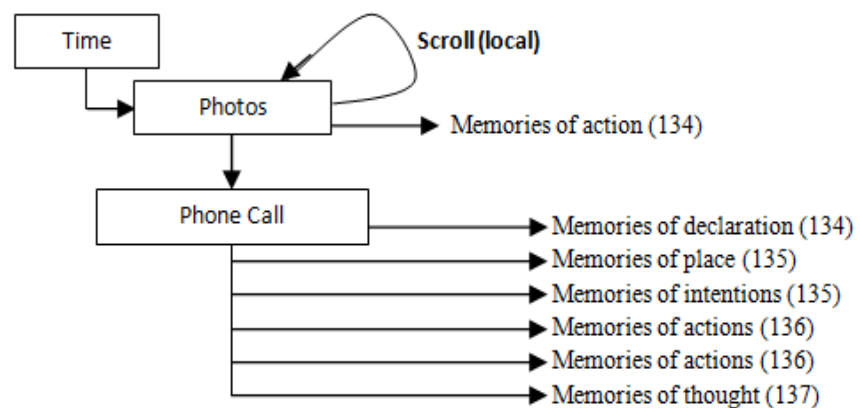
[93] “... we were in the front of the shop”... [94] “... there, I can see my hand and body movements” ... [98] “... that is the bus stop” ... [98] “... we were waiting for the bus” [98] “... I felt that I was very tired and the children as well” ... [99] “... those photos there show he children were drinking their juice “ ... [100] “... those photos taken in the bus” ... [100] “... the bus was crowded, but we got seats” [101] “... there, I can see the house front door movement, we arrived home, and that is the stairs ... [102] “...the children slept in the bus” ...[102] “...they went directly to their beds” ... [103] “...they did not change their cloths”.



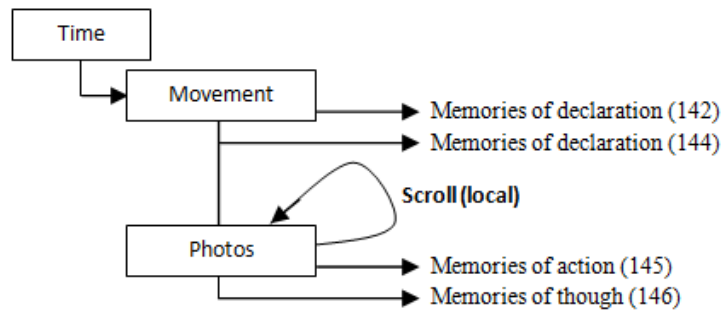
[112] "... I can see there, I moved after the phone call" ... [114] "... those photos show I was in the kitchen" ... [115] "... I made a cup of coffee" ... [116] "... those photos show I was watching the TV and drink my coffee" ... [117] "... there, I can some photos of TV screen shows the news , I could not remember any news" ... [118] "... I can see the screen images of my computer over there ... I checked my email's Inbox" ... [119] "... that email I opened it was from my friend" ... [122] "... not all of these images are mine"... [122] "... I stopped working on computer there" ... [123] "... these images show Cebeebies web site" [123] "... I think it was my daughter " ... [124] "... I was in the kitchen when she used the computer" [125] "... those photos show the food that I prepared for my daughter" ... [126] "...those images are mine, I was serving the internet [127] "... those images there show my Facebook page" ... [127] "... that photo shows my sister and her new baby" [128] "... I was very happy to see here new baby photos"



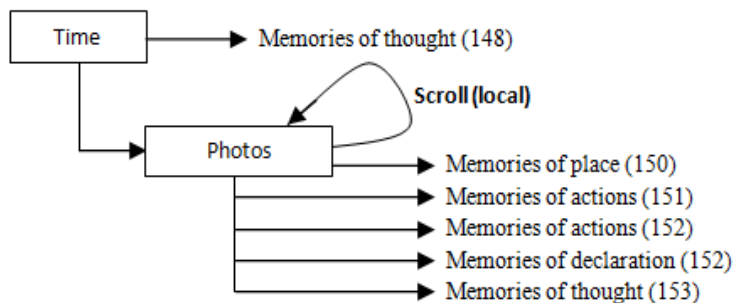
[134] "... I was doing a laundry" [134] "... that phone call was from my sister" ... [135] "... she called me when I was in the Kitchen" [135] "... I was trying to fix the washing machine program" ... [136] "... I spent a long time doing that" ... [136] "... I couldn't fix it, the machine does not start" ... [137] "... I think the children changed the their program".



[142] "... I can see there it was a short significant movement at 21:00" ...
 [144] "... the washing machine worked just for a few minutes" ... [145] "...
 I was watching the TV when the machine start working" ... [146] "... I
 turned it off because it was too late".

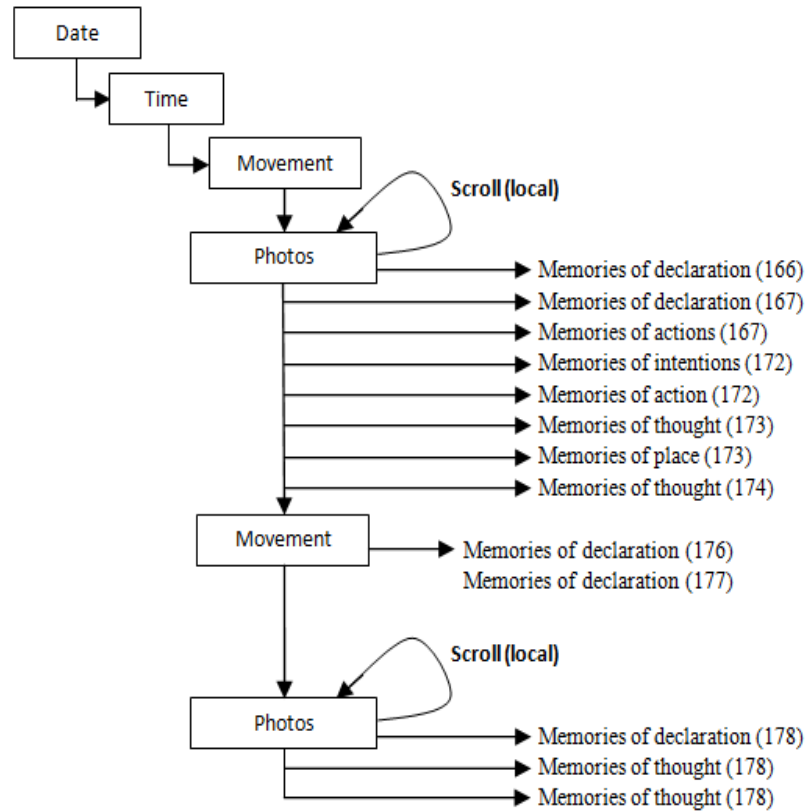


[148] "... we always had our supper between 7 and 8 O'clock night" ...
 [150] "... those photos taken in the kitchen" ... [151] "... I was preparing
 some food" ... [152] "... there, I was cooking" ... [152] "... I can see some
 food on the table" [153] "... it was the first time I cook that food".

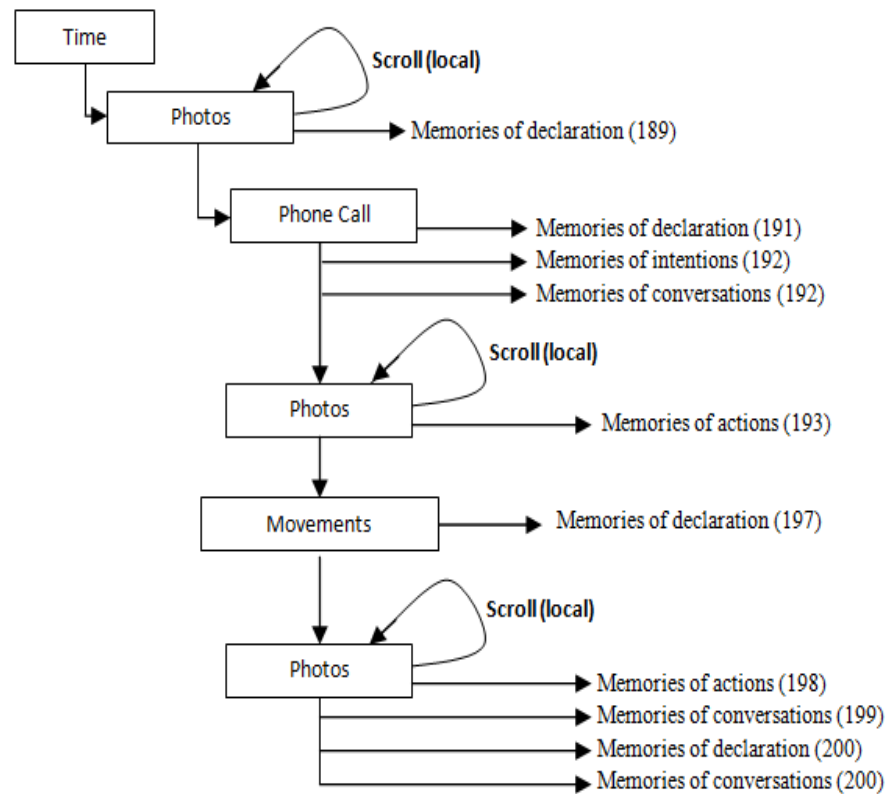


[166] "... I started capturing the photos at 8 am and I stopped at 9 pm" ...
 [167] "... there were some gaps in the photos" ... [167] "... I turned off the
 camera many time" ... [172] "... I was trying to wake up the children" ...
 [172] "... they did not wake up easily" ... [173] "... at night they refused to
 go to their beds early" ... [173] "... that photo shows them in the sitting
 room" ... [174] "... they often sleep again on the sofa" [176] "... that photo
 shows the fridge door, and that is the movement" [177] "... I can see the
 movement of the Kettle and the toaster over there" ... [178] "... that photo
 shows the children bags lunch and that one shows" [178] "...the children

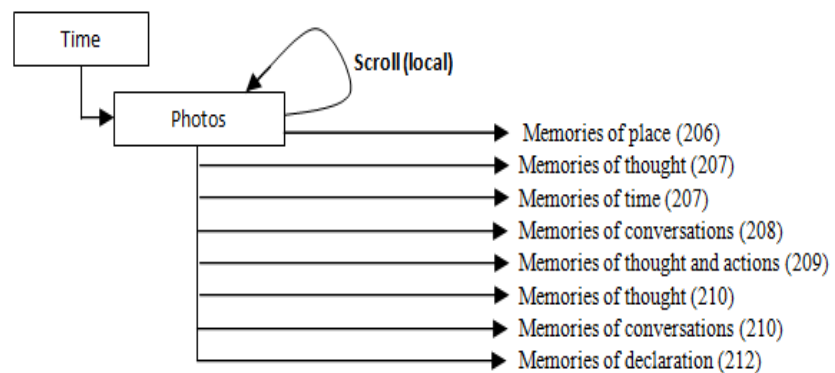
were ready for the school” [179] “...they wear their uniforms without any help”.



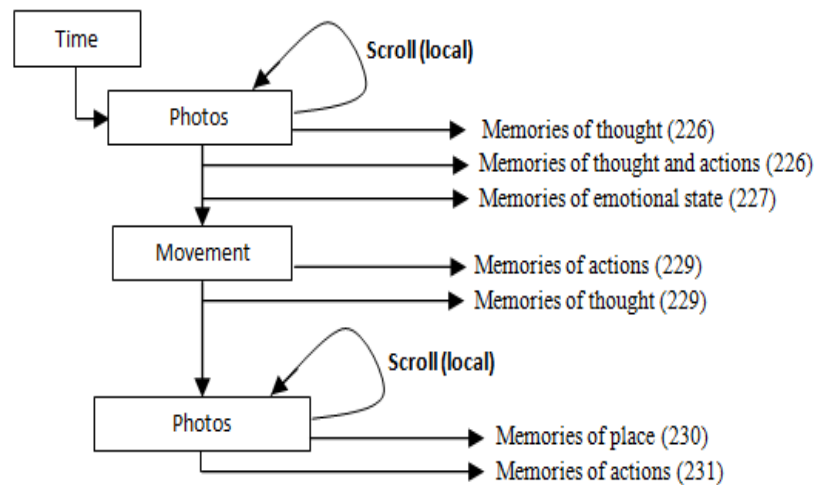
[189] “... I started from the time that the kids went to the school” ... [191] “... that phone call was from my friend” ... [192] “...she called me that morning to tell me about her visa” ... [192] “... I asked her to come and have a cup of tea with me” ... [193] “... I was watching the TV when she called me“ ... [197] “... that is the front door movements ... and that photo shows my friend shoulder” ... [198] “... in that photo my friend showing me her new mobile phone” ... [199] “... she told me she lost her previous phone when she went to London” ... [200] “... my friend does not spent a long time with me” [200] “...she told me she had an appointment with her doctor”.



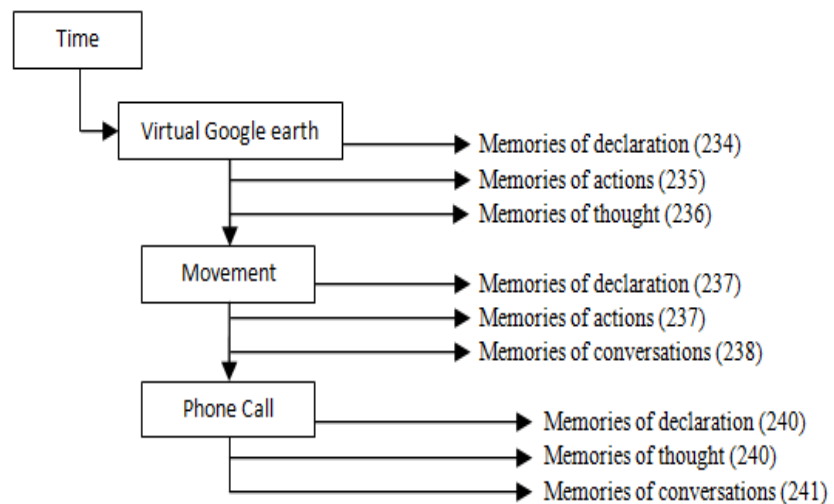
[206] "... those photos shows my friend with me in the Kitchen" ... [207] "... she insists to help me" ... [207] "... we prepared the lunch together" ... [208] "... she said her new house kitchen is very small, and she would like to look for a new house with big kitchen like mine" [209] "... she left after the lunch immediately to catch her an appointment" [210] "... I called her at night and asked her about that" ... [210] "... she told me her doctor asked her to use the same tablet for another one month" ... [212] "... I called here at 21:35 for 7 minutes" .



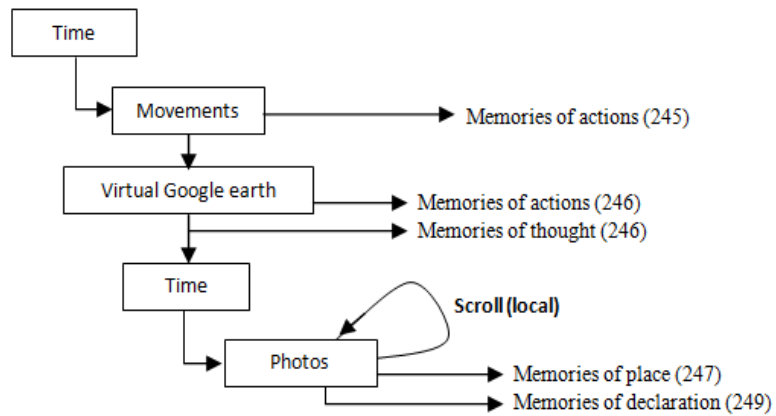
[226] “... I found only a woman with her children” ... [226] “...the Kids were waiting for me with one of their teacher” ... [227] “... they became very happy when they saw me” ... [229] “... I was walking very fast” ... [229] “... I did not meet any children in my way to the school” ... [230] “... that photo shows the main entrance of the school [231] “... that photo shows my daughter running when she saw me”.



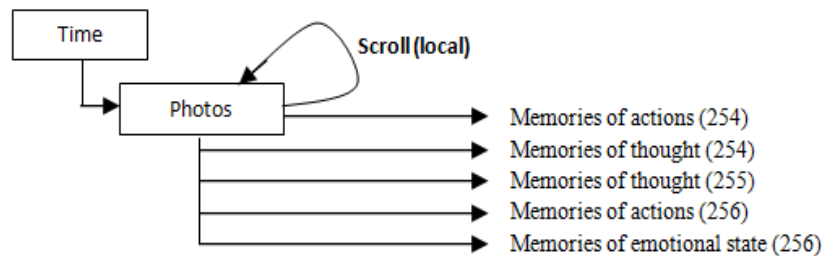
[234] “... that is my path on the virtual Google earth” ... [235] “... the kids were playing in the schoolyard” ... [237] “... I can see no movement over there” ... [237] ... “I had a chat with that woman while we watching the kids” ... [238] ”... she told me about her kids behaviour at night ... she said they refuse to sleep and start fighting when she ask them to sleep” ... [240] “... that phone call I received from my sister”... [240] “... we did not chat for a long time” [241] ... I told her I will call her back at night, but I did not do that, I forgot to do that.



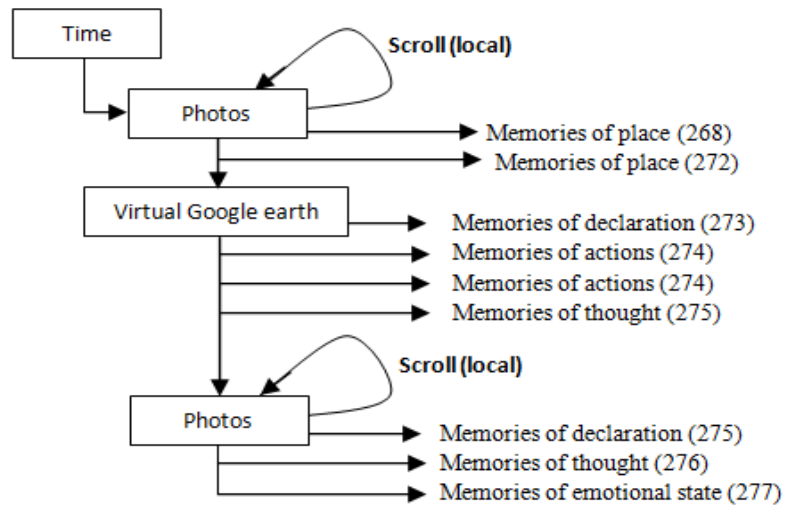
[245] "...I was walking ... I think we were going back home" ... [246] "... on the virtual Google earth we turned left instead of right" ... [246] "... we went to the shop" ... [247] "... those photos shows we are in the shop" ... [249] "... that photo shows we bought some milk as well".



[254] "... I meet one of my English courses classmate" [254] ... I have not seen here for a long time" ... [255] "... she did not finish that course ... she moved to the another Collage" ... [256] "... I invited her to my home" ... [256] "... she is a wonderful woman" .

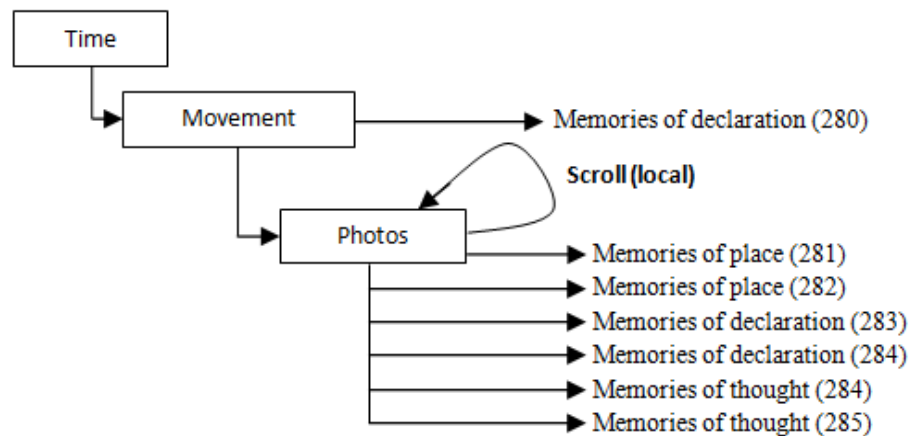


[268] "... all of the photos here captured in the shop" ... [272] "... those photos their show we were out of the shop" ... [273] "... I can see my path and the photos on the virtual Google earth" ... [274] "... I was waiting for my daughter [274] "... she was carrying her bag" ... [275] "... she refused to give it to me" ... [275] "... that photo shows one an old woman with her husband" ... [276] "... many times I meet that couple in my way to the school" ... [276] "... they love children ... many times they talked with the kids" ... [277] "... they are very kind people".



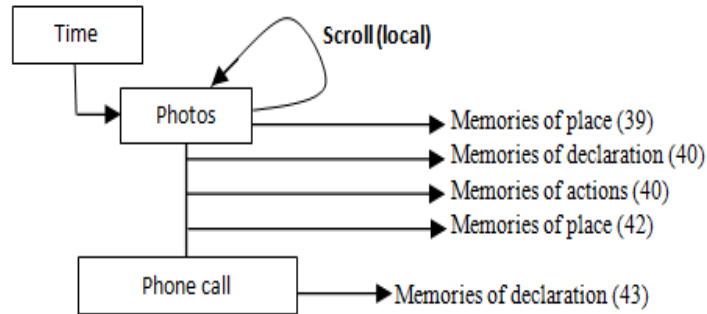
[280] “ ... I need to locate the time of the front door movement first” ...

[281] “... those photos taken in the house” ... [282] “... that photo shows the kitchen” ... [283] “... that photo shows my son was playing games on the computer” ... [284] “... he was still wearing his uniform” ... [284] “... many times he did that” ... [285] “... he neither change his dress nor wash his hands” .

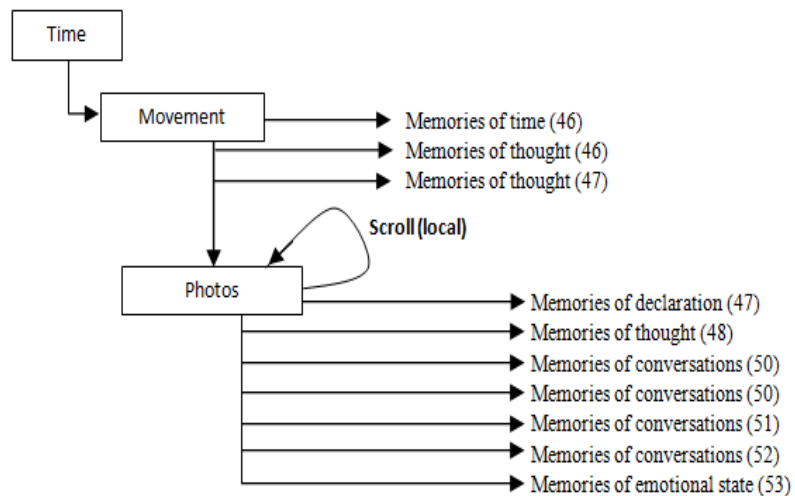


Appendix R31

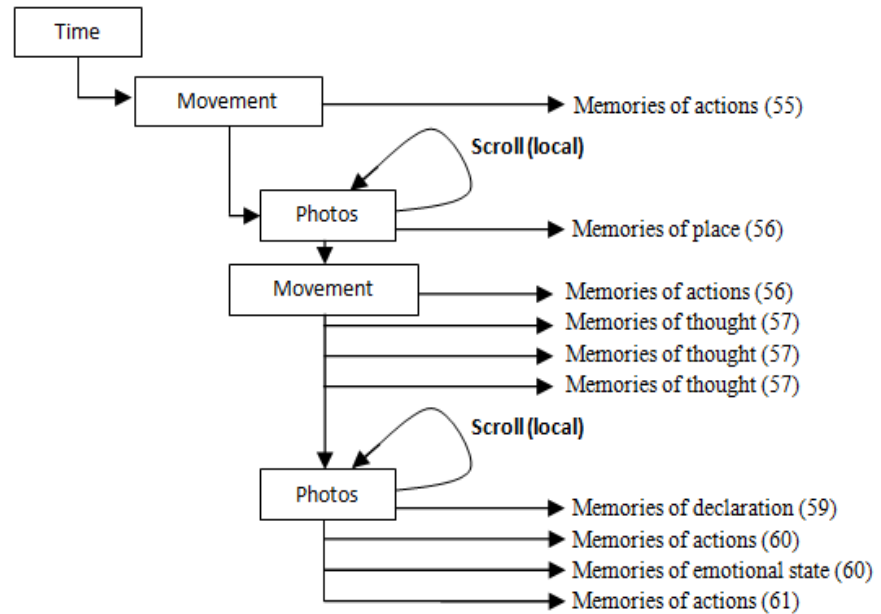
[39] "... that is the Haymarket metro station" ... [40] "... that is my friend in the cashier talking to the banker" ... [41] "... I was sitting and waiting for my friend" ... [42] "... those photos taken in the high street" ... [43] "... that missing phone call was from my brother".



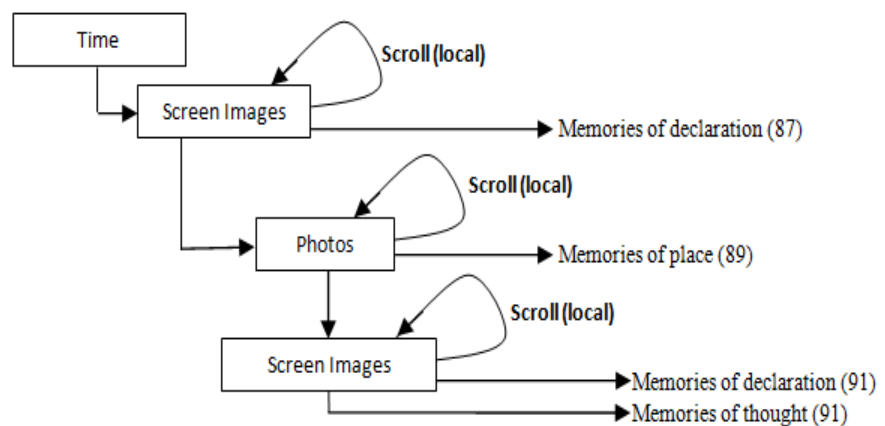
[46] "... we were sitting for lunch" ... [46] "... that place just opened [47] "... my friend recommended that place" ... [47] "... that photo there shows my plate" ... [48] "... the food was little spicy" ... [50] "...my friend told me about the first time she has been there" ... [50] "... she said, few weeks ago she visited that place with her husband and the children, they enjoyed the place and the food" ... [51] "... she told me about her Mum and how she missed her" ... [52] "... she talked about her childhood" ... [52] "... she said her Mum was her best friend, she love her so much" ... [53] "... I felt very sad when I saw her tears ".



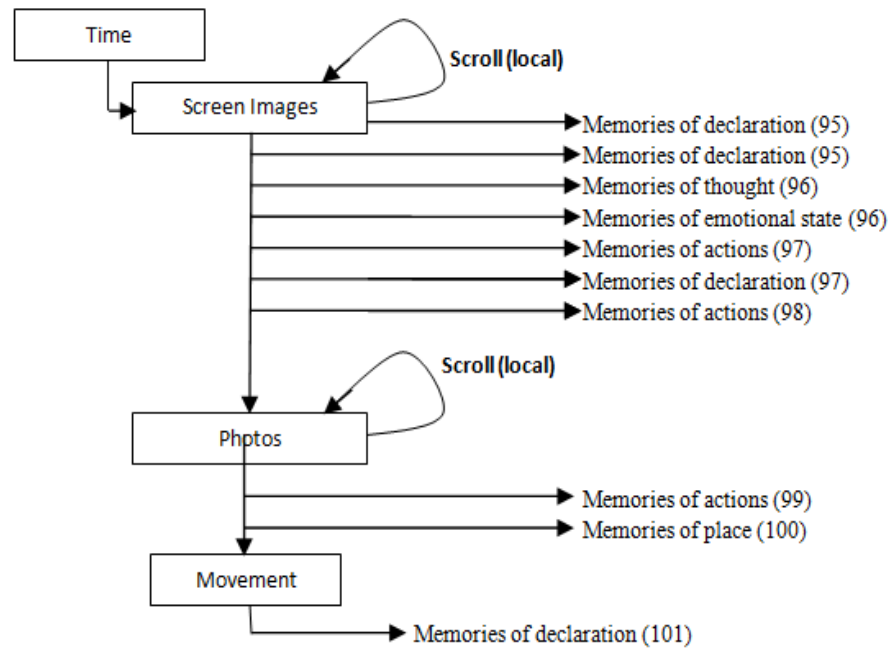
[55] "... here, I was walking" ... [56] "... those photos there show the high street again" ... [56] "... we stopped in front of the shop" [57] "... my friend saw a Fridge offer" [57] "... she was looking for one for her new house" ... [59] "... many people appear in that photo" ... [60] "... we were watching a man playing on his old musical instrument" ... [60] "... he was playing very well I liked his music" ... [61] "... many people clapped for him at the end".



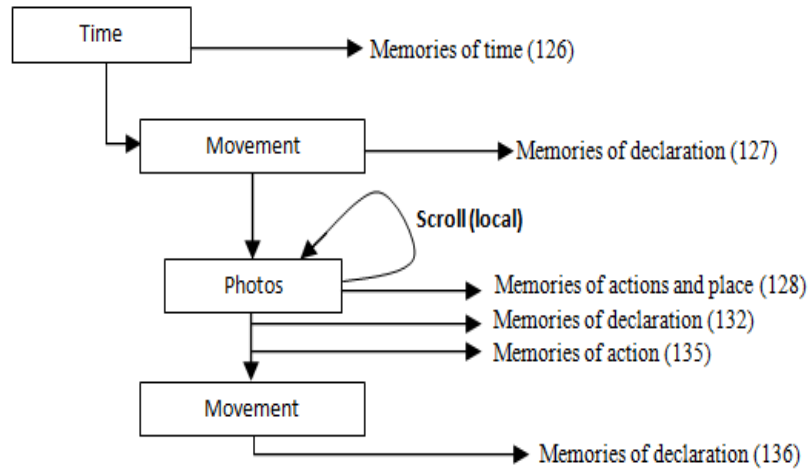
[87] "... I can see the graphs in many hours' pane, but not all of them was mine" ... [89] "... this graph shows that the computer used on that hour and those photos show the backyard of the house " [91] "... almost of the images show the games and children web sites" ... [91] "... the kids used the computer many times".



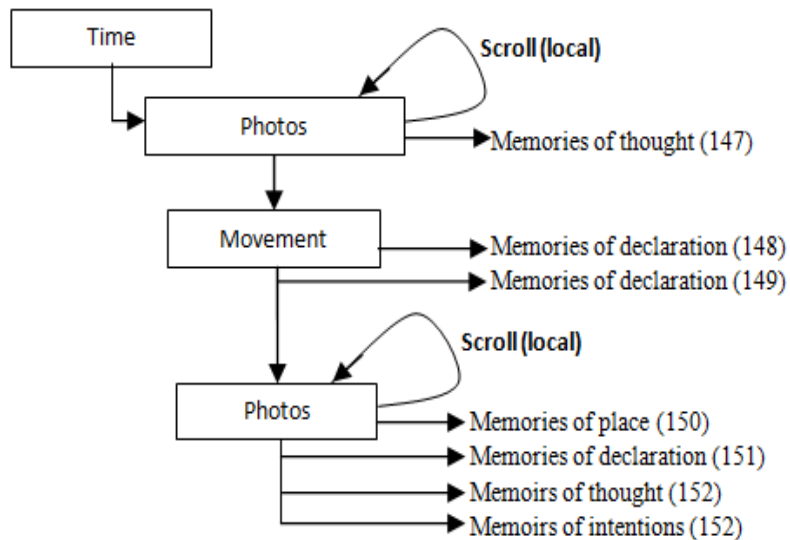
[95] “... those images there show me serving the internet” ... [95] “... that email I received from my sister” ... [96] “... she wrote her son passed his exam” ... [96] “... I was very happy to know that” ... [97] “... I sent her an email immediately it’s there” ... [97] “... those screen images show I was checking the Facebook” ... [98] “... I uploaded some photos to my account” ... [99] “... that photo shows I was talking to the children” ... [100] “... I was in the kitchen” ... [100] “... that is the fridge door and the kettle movements” [101] “... I was preparing some food for the children”.



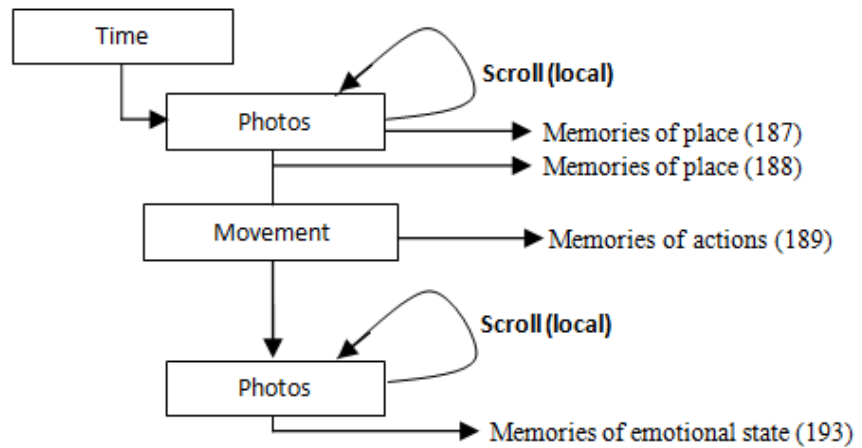
[126] “... this is the time of the children school” ... [127] “... I can see no significant movement of my body or hand” ... [128] “... I was in the sitting room watching the TV” ... [132] “... I did not spend a long time of that” ... “[135] “... those photos show I was doing laundry” ... [136] “... there I can see a significant movement of my body and the movement of the front door”.



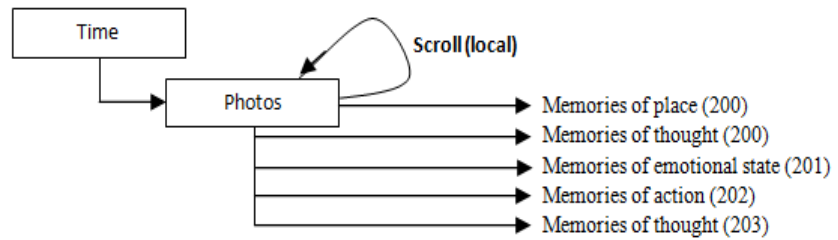
[147] “... we did not spend a long time in the house” ... [148] “... this movement shows when my friend came” ... [149] “... that movement shows when we went out”. [150] “... that photo shows we were in the main street” ... [151] “... that photo shows the phone” ... [152] “... the sky was clear I can see my path starts very close to the house” ... [152] “... our destination was the city centre”.



[187] “... there we were in the shop” ... [188] “... those photos taken at the high street” ... [189] “... we sat for a long time” ... [193] “... my friend does not stop laughing when she saw a man dancing in front of people” .



[200] "... that is the the main entrance of the restaurant" ... [200] "... it is not far away from the monument" ... [201] "... I was confused" ... [202] "... I kept silent when the waitress asked me about the food" ... [202] "... we both ordered the same food".



[223] "... often we arrive at home before 4 O'clock" ... [224] "... I can see the main door movement their" ... [226] "... they did not sleep" ... [227] "... they played in the backyard and played games on computer".

